VOLCANO

REPORT FOR THE

DEPARTMENT OF ENERGY, MINES AND RESOURCES
CANMET ENERGY RESEARCH LABORATORIES
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INSTALLATION AND EVALUATION OF NOVEL PULVERIZED COAL BURNERS FOR THE COMBINED REDUCTION OF NITROGEN AND SULPHUR OXIDES DURING COMBUSTION AT CFB GAGETOWN, N.B.

DIRECT DESULPHURIZATION THROUGH ADDITIVE INJECTION IN THE VICINITY OF THE FLAME

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ABSTRACT

THE PRIME OBJECTIVES OF THIS PROJECT WERE TO DEMONSTRATE AND TO ADVANCE THE TECHNOLOGY FOR THE SIMULTANEOUS REDUCTION OF NITROGEN AND SULPHUR OXIDES (NO_x AND SO_x) IN PULVERIZED-COAL FLAMES BY USING A STAGED MIXING BURNER WITH INJECTION OF A SULPHUR SORBENT AROUND THE FLAME.

THE BOILER AT THE GAGETOWN C.H.P. PROVIDED AN IDEAL OPPORTUNITY FOR THE PROJECT BECAUSE OF ITS RELATIVELY SMALL SIZE AND THE FACT THAT EACH BURNER HAS ITS OWN PULVERIZER. HOWEVER, THE NEED TO MAINTAIN BOILER AVAILABILITY AT ALL TIMES DURING THE HEATING SEASON REQUIRED STRINGENT PLANNING TO LIMIT ANY DISRUPTIONS CAUSED BY THE INSTALLATION WORK.

THIS REPORT OUTLINES, IN DETAIL, THE BASIC DESIGN AND FUNCTION OF THE STAGED MIXING BURNER TECHNOLOGY.

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LIAISON ENGINEERS FOR THIS PROJECT WERE:

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EXECUTIVE SUMMARY

ENERGY MINES AND RESOURCES CANADA HAS FOR SEVERAL YEARS INVESTIGATED POSSIBLE WAYS TO ADVANCE COAL BURNING EQUIPMENT TECHNOLOGY FOR SIMULTANEOUS REDUCTION OF NITROGEN AND SULPHUR OXIDES (NO_x AND SO_x) DURING COMBUSTION. GENERATOR UNIT NO. 2 AT THE CENTRAL HEATING PLANT OFCANADIAN FORCES BASE GAGETOWN WAS SELECTED FOR EVALUATION AND DEMONSTRATION OF A CONCEPT TO REDUCE NO_x AND SO_x EMISSIONS BY MORE THAN 50 PERCENT. THIS CENTRAL HEATING PLANT COMPRISES 3 X 20 MW HIGH TEMPERATURE HOT WATER UNITS, EACH EQUIPPED WITH (2) TWO RO BURNERS MOUNTED ON THE FRONT WALL.

THE L & C STEINMUELLER BURNER AND ADDITIVE DESIGN TECHNOLOGIES WERE USED. MODIFICATIONS TO THE COMBUSTION EQUIPMENT WERE UNDERTAKEN TO REPLACE EXISTING BURNERS TO "DENO$_x$ - DESO$_x$" SM-BURNERS. THE SM-BURNER IS CAPABLE OF REDUCING ACID GAS EMISSIONS BY MORE THAN 50 PERCENT.

AS STATED PREVIOUSLY, THE WORK ON THIS PROJECT WAS CONDUCTED UNDER THE AUSPICES OF THE CANADA CENTRE FOR MINERAL AND ENERGY TECHNOLOGY, ENERGY, MINES AND RESOURCES CANADA (E.M.R.) THROUGH A DSS CONTRACT TO VOLCANO INC. TO CARRY OUT THE FOLLOWING:

EXECUTIVE SUMMARY (CONT'D)

- THE DEVELOPMENT, SUPPLY AND TESTING OF TWO (2) RETROFIT PULVERIZED COAL BURNERS CAPABLE OF SIMULTANEOUSLY REDUCING SULPHUR AND NITROGEN EMISSIONS TO SPECIFIED LEVELS WHILE BURNING COAL ONLY.

- THE DEVELOPMENT, SUPPLY AND TESTING OF A POWDERED ADDITIVE UNLOADING, STORAGE, FEEDING, METERING AND INJECTION SYSTEM.

- THE INSTALLATION, COMMISSIONING AND PERFORMANCE EVALUATION UNDER FIELD OPERATING CONDITIONS.

FOR ALL THE TESTS, ENVIRONMENT CANADA WAS RESPONSIBLE FOR MONITORING EMISSIONS OF SO_x, NO_x, CO, CO_2 AND O_2.

G.A. ROBB ASSOCIATES WERE RESPONSIBLE FOR COAL AND ASH SAMPLING, FOR RECORDING OPERATING DATA AND FOR BOILER EFFICIENCY DETERMINATION.

THE COMBUSTION AIR DUCTS FROM DOWNSTREAM OF THE TUBULAR AIR HEATER WERE REPLACED IN ORDER TO PROVIDE A DEDICATED AIR SUPPLY TO EACH AIR COMPARTMENT OF EACH

EXECUTIVE SUMMARY (CONT'D)

BURNER. THIS WAS DONE TO MAKE THE RETROFIT SIMPLER AND TO SAFELY ALLOW THE EXECUTION OF A TESTING PROGRAM. A BLENDING OF PRIMARY AIR AND HOT FURNACE GASES WAS USED TO TRANSPORT THE PULVERIZED COAL TO THE BURNERS.

IN SPITE OF THE NARROWER OPERATIONAL LIMITS OF THE OTHER UNMODIFIED EQUIPMENT. THE GUARANTEED GOAL OF 50 PERCENT NO_x AMD 50 PERCENT SO_x REDUCTION WAS ACHIEVED IN THE BOILER DEMONSTRATION TESTS.

FURTHERMORE, A BURNER LOAD DEPENDENT ON AUTOMATIC SECONDARY/TERTIARY AIR FLOW CONTROL SYSTEM WAS DEVELOPED AND INTRODUCED SUCCESSFULLY TO GUARANTEE SAFE BURNER OPERATION AT LOW NO_x LEVELS OVER A WIDE TURN DOWN RATIO. A FLAME SAFEGUARD SYSTEM HAS ALSO BEEN TESTED TAKING INTO CONSIDERATION ADDITIVE INJECTION AND UPGRADED COMBUSTION CONTROLS. THE SYSTEM HAS PROVEN TO BE VERY RELIABLE IN OPERATION.

1.0 INTRODUCTION

IN VIEW OF THE RISING COST OF RESIDUAL FUEL OIL AND ANTICIPATED NEW FEDERAL AND PROVINCIAL INITIATIVES ON EMISSIONS FROM STATIONARY COMBUSTION SYSTEMS, NO_x AND SO_x EMISSION LEVELS WILL IN ALL LIKELYHOOD, BE SUBJECT TO PROGRESSIVELY MORE STRINGENT CONTROLS.

ASIDE FROM EXISTING STATIONARY COMBUSTION SYSTEMS, THE GENERAL TREND IS AGAIN TO ALTERNATIVE FORMS OF ENERGY, OF WHICH THE IMMEDIATE CHOICE IS COAL. THE GROWING USE OF COAL, HOWEVER, WILL FURTHER INCREASE BOTH SO_x AND NO_x, AS WELL AS PRODUCING INCREASED QUANTITIES OF DUST, UNLESS EFFECTIVE MEASURES ARE TAKEN TO REDUCE THESE EMISSIONS.

FUTURE GOVERNMENT REGULATIONS ON NO_x AND SO_x EMISSIONS FOR POWER STATION BOILERS WILL FORCE UTILITIES AND BOILER MANUFACTURERS TO DEVELOP TECHNIQUES WHICH ALLOW THE OPERATION OF BOILERS IN COMPLIANCE WITH PRESENT AND FUTURE REGULATIONS.

1.0 INTRODUCTION (CONT'D)

IT HAS BEEN SHOWN BY VARIOUS INTERNATONAL R & D PROGRAMS, THAT ONE METHOD TO CONTROL THE EMISSIONS OF NO_x AND SO_x IS BY FLAME MODIFICATION. THE REDUCTION OF NO_x BY STAGED-MIXING BURNERS IS WELL KNOWN AND PRACTISED SUCCESSFULLY.

THE REDUCTION OF SO_x BY MODIFYING THE COMBUSTION PROCESS IS EXTREMELY DIFFICULT BECAUSE THE FORMATION OF SULPHUR DIOXIDE DURING COMBUSTION PARALLELS THE FORMATION OF CO_2. THUS AN ECONOMIC WAY FOR IN SITU DESULPHURIZATION IS BY THE INJECTION OF A SORBENT SUCH AS $CaCO_3$ OR $Ca(OH)_2$ INTO THE FURNACE.

A DESULPHURIZATION PROCESS FOR BROWN COAL FIRING SYSTEMS, IN WHICH THE ADDITIVE IS MIXED WITH THE FUEL BEFORE THE LATTER REACHES THE BURNER, HAS BEEN WIDELY TESTED WITH SUCCESSFUL RESULTS. WHEN SIMILAR PROCESSES WERE USED IN BITUMINOUS COAL FIRING SYSTEMS THE DEGREE OF DESULPHURIZATION ACHIEVED WAS MARKEDLY INFERIOR. THE REASON FOR THIS IS OBVIOUSLY THE HIGHER FLAME TEMPERATURE SINCE THE

1.0 INTRODUCTION (CONT'D)

ADDITIVES ARE SUBJECTED TO THE WHOLE SPECTRUM OF FLAME TEMPERATURES AND MUST TRAVERSE TEMPERATURE BANDS WHICH CAN DECOMPOSE ANY SULPHATE COMPOUNDS ALREADY FORMED AND CAUSE SINTERING OF THE SURFACE OF THE ADDITIVE PARTICLES.

INJECTION OF ADDITIVE ABOVE THE FLAME REGION INTO THE FURNACE BY AIR JETS HAS ALSO BEEN INVESTIGATED IN PILOT PLANTS. THE RESULTS WERE CONSIDERABLY BETTER THAN WHEN THE ADDITIVE WAS MIXED WITH THE FUEL. THESE PROCESSES ONLY OFFER PROSPECTS OF SUCCESS IN SMALL BOILERS. THE DISADVANTAGE INHERENT IN THE METHOD IS THAT THE INJECTION OF ADDITIVE INTO THE FURNACE DEMANDS VERY HIGH ENERGY ON THE PART OF THE JETS IF GOOD MIXING OF REACTANT AND SULPHUR ARE TO BE ATTAINED.

THIS IS HARDLY PRACTICABLE, PARTICULARLY IN THE ENORMOUS GAS FLOWS OF LARGE UNITS. ADDITIONALLY, THIS MIXING WOULD TEND MAINLY TO OCCUR JUST IN THAT PORTION OF THE BOILER WHERE TEMPERATURE AND RESIDENCE TIME ARE AT THEIR MOST UNFAVOURABLE FOR

1.0 INTRODUCTION (CONT'D)

THE REACTION BETWEEN ADDITIVE AND SULPHUR WHICH RESULTS IN THE REMOVAL OF THE LATTER.

AFTER A THOROUGH ANALYSIS OF THE ABOVE MENTIONED DESULPHURIZATION PROCESSES AND THE TECHNICAL PROBLEMS INVOLVED, AND BECAUSE DIRECT INJECTION OF ADDITIVE IS SUCH AN ATTRACTIVE PROSPECT DUE TO LOW INVESTMENT COSTS, A PROCESS WAS DEVELOPED WHICH OFFERED A MUCH BETTER CHANCE OF ACHIEVING THE NECESSARY PRE-CONDITIONS FOR FURNACE SULPHUR REMOVAL WITH RESPECT TO TEMPERATURE, MIXING AND RESIDENCE TIME EVEN FOR HIGH CALORIFIC VALUE FUELS AND AT AN ECONOMIC COST.

2.0 STATEMENT OF WORK

2.1 EQUIPMENT AND SERVICES

2.1.1 THE DEVELOPMENT, SUPPLY AND EVALUATION OF TWO EXPERIMENTAL RETROFIT PULVERIZED COAL BURNERS CAPABLE OF SIMULTANEOUSLY REDUCING SULPHUR AND NITROGEN OXIDES EMISSIONS TO SPECIFIED LEVELS WHILE BURNING COAL ONLY IN BOILER NO. 2 AT THE CANADIAN FORCES BASE (CFB) GAGETOWN.

2.1.2 THE DEVELOPMENT, SUPPLY AND EVALUATION OF A POWDERED ADDITIVE UNLOADING, STORAGE, FEEDING, METERING AND INJECTION SYSTEM.

2.1.3 THE INSTALLATION, COMMISSIONING, PERFORMANCE EVALUATION AND MODIFICATION AS REQUIRED OF THE BURNERS AND THE LIMESTONE OR ADDITIVE SYSTEM UNDER FIELD OPERATING CONDITIONS.

2.2 PERFORMANCE REQUIREMENTS

2.2.1 THE RETROFIT BURNERS AND CALCIUM INJECTION SYSTEM SHALL BE A COMPLETE PACKAGE COMPATIBLE WITH THE EXISTING BOILER, ANCILLARIES AND AVAILABLE SPACE.

2.0 STATEMENT OF WORK (CONT'D)

2.2.2 THE INTEGRATED BURNER AND ADDITIVE SYSTEM TO BE DEVELOPED AND SUPPLIED SHALL BE GUARANTEED TO MEET THE FOLLOWING REQUIREMENTS:

a) NITROGEN OXIDE AND SULPHUR DIOXIDE LEVELS SHALL BE REDUCED BY 50% OR MORE WITHOUT SUPPORT FIRING AT FULL LOAD IN BOILER NO. 2 WHILE BURNING THE COAL SPECIFIED IN SECTION 2.4.0 WITH HAVELOCK LIMESTONE INJECTION. THE LIMESTONE ADDITION RATE SHALL NOT EXCEED A Ca/S MOL RATIO OF 2.5 TO ACHIEVE THE SPECIFIED LEVEL OF SO_x REDUCTION. FOR PURPOSES OF THIS REQUIREMENT THE NO_x LEVEL IS CONSIDERED TO BE 500 PPM CORRECTED TO 3% AND THE SO_x LEVEL IS CONSIDERED TO BE 1900 PPM CORRECTED TO 3% OXYGEN. THUS, THE NO_x TARGET IS 250 PPM CORRECTED TO 3% OXYGEN AND THE SO_x TARGET IS 950 PPM CORRECTED TO 3% OXYGEN. NO_x AND SO_x LEVELS WILL BE DETERMINED BY ENVIRONMENT CANADA EPS METHODS, EPS-1-AP-77-3 AND EPS-1-AP-74-3 RESPECTIVELY.

b) WHILE OPERATING AT FULL LOAD ON COAL ONLY, WITH COMBUSTION AIR AND CALCIUM SET TO PROVIDE

2.0 STATEMENT OF WORK (CONT'D)

THE GUARANTEED NO_x AND SO_x LEVELS, THE BOILER EXIT TEMPERATURE SHALL NOT EXCEED 390°C WITH SOOT-BLOWING AT CONSECUTIVE FOUR (4) HOUR INTERVALS.

I) THE FLAME LENGTH SHALL NOT EXCEED THOSE IN CURRENT OPERATION; IMPINGEMENT OF FLAME ON BOILER SIDE, FRONT OR BACK WALLS IS UNACCEPTABLE.

II) THE FIRESIDE DEPOSITS IN THE BOILER SHALL REMAIN DRY AND BE REMOVABLE WITH THE EXISTING SOOT BLOWERS; SLAGGING OR FOULING OF BOILER SURFACES MUST NOT OCCUR.

III) COMBUSTIBLE IN FLY ASH SHALL NOT EXCEED 7% BY WEIGHT BEFORE THE SETTLING CHAMBER COLLECTOR.

IV) COMBUSTION EFFICIENCY AS DETERMINED BY THE ASME PTC-4.1-1964 HEAT LOSS METHOD SHALL NOT BE LESS THAN 82% AT FULL LOAD ON COAL ONLY.

2.0 STATEMENT OF WORK (CONT'D)

2.3 SCOPE OF RESEARCH AND DEVELOPMENT

2.3.1 THE FOLLOWING TECHNOLOGY WAS DEVELOPED AND SUPPLIED.

2.3.2 BURNERS COMPLETE WITH PROPANE GAS IGNITORS, PRIMARY, SECONDARY AND TERTIARY AIR PORTS, NOZZLES FOR ADDITIVE INJECTION, MAIN AIR SUPPLY CONNECTION INCLUDING DAMPERS, CONNECTIONS TO EXISTING EXHAUSTER FANS, EXPANSION JOINTS, AIR FLOW MEASURING DEVICES FOR EACH BURNER AND ITS STAGING ZONES AND FOR EACH LIMESTONE INJECTION ZONE.

2.3.3 BURNER MANAGEMENT SYSTEM CONSISTING OF:

I) FLAME DETECTION SYSTEMS FOR OIL AND COAL FIRING INCLUDING FLAME DETECTORS, CONTROL UNITS AND CABLING TO EXISTING MAIN CONTROL PANEL.

II) BURNER CONTROL SYSTEM TO PROVIDE SAFE OPERATION WHILE FIRING COAL ONLY INCLUDING ANY NECESSARY CONTROLS, DAMPERS AND INTERFACING WITH FLOW MEASUREMENT DEVICES.

2.0 STATEMENT OF WORK (CONT'D)

2.3.4 ADDITIVE STORAGE AND INJECTION SYSTEM INCLUDING SILO, TRUCK DELIVERY LINE, FEEDERS, AIR COMPRESSORS, PIPING, EXHAUST AIR DUST FILTER, FLUIDIZATION EQUIPMENT, VALVES AND ALL NECESSARY CONTROLS AND INSTRUMENTATION. ON-LINE WEIGHING OF ADDITIVE DURING USE WAS PROVIDED.

2.0 STATEMENT OF WORK (CONT'D)

2.4 COAL ANALYSIS USED FOR DESIGN PURPOSES

COAL ANALYSIS

ULTIMATE ANALYSIS,	WT %	SULPHUR FORMS,	WT %
CARBON	75.2	SULPHATE	0.4
HYDROGEN	4.8	PYRITE	1.8
SULPHUR	3.0	ORGANIC (DIFF.)	0.8
NITROGEN	1.4		3.0
ASH	10.0		
OXYGEN (DIFF.)	5.6		
	100.0		

PROXIMATE ANALYSIS, WT %	AS REC'D	DRY
MOISTURE	10.0	0.0
VOLATILE MATTER	30.0	33.0
FIXED CARBON	51.0	57.0
ASH	9.0	10.0
	100.0	100.0

SCREEN ANALYSIS

SCREEN SIZE	WT %	SCREEN SIZE,	WT %
+ 1-1/2 in.	0.4	3/4 x 1/2 in.	11
1-1/2 x 1 in.	4	1/2 x 1/4 in.	22
1 x 3/4 in.	6	1/4 x 1/8 in.	25

HIGHER HEATING VALUE, DRY: 33.3 MJ/KG
HARD GROVE GRINDABILITY INDEX: 59

2.0 STATEMENT OF WORK (CONT'D)

ASH ANALYSIS

ASH COMPOSITION,	WT %
SiO_2	35.0
AL_2O_3	19.5
Fe_2O_3	39.6
TiO_2	1.0
P_2O_5	0.2
CaO	1.8
MgO	1.0
SO_3	2.1
Na_2O	0.4
K_2O	1.6

ASH FUSION TEMPERATURE °C

	OXIDIZING	REDUCING
INITIAL	1345	1080
SPHERICAL	1390	1175
HEMISPHERICAL	1400	1260
FLUID	1410	1330

2.0 STATEMENT OF WORK (CONT'D)

2.5 SEIVE ANALYSIS OF DESIGN LIMESTONE DUST

ADDITIVE DATA:

RANGE OF MOLAR RATIO	Ca/S	4 TO 1
FLOW RANGE	$Ca(OH)_2$	4.61 L/MIN. - 36.9 L/MIN.
	$CaCO_3$	2.48 L/MIN. - 19.85 L/MIN.

CaO CONTENT OF $Ca(OH)_2$	74%
CaO CONTENT OF $CaCO_3$	55%

SPECIFIC SURFACE AREA

$Ca(OH)_2$	1.86 M^2/g (BLAINE)
	14.8 M^2/g (BET)
$CaCO_3$	0.456 M^2/g (BLAINE)
	1.45 M^2/g (BET)

BULK DENSITY:

$Ca(OH)_2$	400 Kg/M^3
$CaCO_3$	1000 Kg/M^3

PARTICLE DENSITY:

$Ca(OH)_2$	2230 Kg/M^3
$CaCO_3$	2711 Kg/M^3

2.0 STATEMENT OF WORK (CONT'D)

2.5 SEIVE ANALYSIS OF DESIGN LIMESTONE DUST

PARTICLE SIZE DISTRIBUTION:

$Ca(OH)_2$: AERODYNAMIC SEPARATION

GREATER THAN	200 x 10-6 M	0%
	90	0.8%
	63	2.2%
	45	4.8%
	32	12.0%

BAHCO TECHNIQUE

GREATER THAN	45.5 x 10-6 M	8.1%
	30.1	12.4%
	12.4	18.3%
	5.6	35.3%
	3.2	60.6%
	2.1	82.0%

$CaCO_3$: AERODYNAMIC SEPARATION

GREATER THAN	200 x 10-6 M	0%
	90	7.2%
	63	14.4%
	45	22.2%
	32	25.8%

BAHCO TECHNIQUE

GREATER THAN	41.3 x 10-6 M	33.5%
	27.3	40.8%
	11.2	49.7%
	5.1	68.6%
	2.9	86.1%
	1.9	94.7%

2.0 STATEMENT OF WORK (CONT'D)

2.6 DESIGN VARIATION IN COAL ANALYSIS.

THE SM BURNERS HAVE BEEN DESIGNED TO BURN COALS FROM VARIOUS SOURCES HAVING THE RANGE OF PROPERTIES AS FOLLOWS:

ULTIMATE ANALYSIS	WT % RANGE
CARBON	72 - 79
HYDROGEN	4.5 - 5.0
SULPHUR	3.0
NITROGEN	1.4
ASH	8 - 12
OXYGEN	BY DIFFERENCE

PROXIMATE ANALYSIS	AS RECEIVED WT % RANGE
MOISTURE	8 - 12
VOLATILE MATTER	29 - 33
FIXED CARBON	48 - 53
ASH	8 - 12

SCREEN ANALYSIS:

SCREEN SIZE	WT %
+ 1-1/2" in.	0.4
1-1/2 x 1 in.	4
1 x 3/4 in.	6
3/4 x 1/2 in.	11
1/2 x 1/4 in.	22
1/4 x 1/8 in.	25

HIGHER HEATING VALUE, DRY: >30 MJ/KG

HARDGROVE GRINDABILITY INDEX: > 55

ASH FUSION TEMPERATURE: °C	OXIDIZING	REDUCING
INITIAL	1345	1080
SPERICAL	1390	1175
HEMI SPERICAL	1400	1260
FLUID	1410	1330

2.0 STATEMENT OF WORK (CONT'D)

2.7 BOILER FULL LOAD (MCR) OPERATING CONDITIONS

NUMBER OF BURNERS	2
CAPACITY OF EACH BURNER (MAX. ADMISSABLE THERMAL CAPACITY)	12.5 MW
BOILER OPERATION:	100% LOAD WITH BOTH BURNERS
	50% LOAD WITH LOWER BURNER

COAL TYPE		BITUMINOUS
HIGH HEATING VALUE, DRY		33.3 MJ/Kg
TEMPERATURE AFTER MILL	°C	90
TEMPERATURE BEFORE MILL	°C	272
HOT AIR TEMPERATURE	°C	180
GAS/COAL RATIO	Kg/Kg	1.5
TOTAL FUEL FLOW	Kg/s	0.868
MAX. COAL FLOW RATE/BURNER	Kg/s	0.434
SPECIFIC AIR DEMAND	Kg/Kg	9.2

3.0 CONTROL OF NO_x EMISSIONS

3.1 NO_x FORMATION

NUMEROUS STUDIES OF A THEORETICAL AND EXPERIMENTAL NATURE HAVE SHOWN THAT NO_x EMISSIONS FROM PULVERIZED FUEL SYSTEMS CAN BE ACCREDITED TO TWO SOURCES:

- THERMAL NO_x FORMATION EVOLVING FROM THE OXIDATION OF NITROGEN WHICH, AT LEAST PRIOR TO THE ONSET OF COMBUSTION REACTION, IS PRESENT IN MOLECULAR FORM, E.G. ATMOSPHERIC NITROGEN. THIS REACTION HEAVILY DEPENDS ON THE TEMPERATURE.

- FUEL NO_x FORMATION EVOLVES FROM THE OXIDATION OF FUEL BOUND NITROGEN. BECAUSE OF THE INHERENTLY LOWER ENERGY OF ACTIVATION, NO_x OXIDATION MAY OCCUR IN A FAIRLY LOW TEMPERATURE ENVIRONMENT WHEN NITROGEN-CARBON COMPOUNDS ARE FORMED IN THE COURSE OF COMBUSTION. HENCE, THIS REACTION MAINLY DEPENDS ON THE OXYGEN CONCENTRATION IN THE REACTION ZONE.

IN THE STAGED MIXING BURNER, AS INSTALLED AT CFB GAGETOWN, COMBUSTION PROCEEDS AS SHOWN IN FIG. NO. 83150-A2.

THE RELATIVE IMPORTANCE OF THESE INDIVIDUAL REACTION ROUTES ON THE OVERALL NO_x FORMATION, VARIES WITH THE NITROGEN CONTENT OF THE FUEL.

3.0 CONTROL OF NO_x EMISSIONS (CONT'D)

3.2 STAGED MIXING BURNER CONCEPT FOR NO_x REDUCTION

FIG. 83150-A2 SHOWS AN SM-BURNER SCHEMATIC REVEALING ITS DEVIATION FROM THE RELIABLE CIRCULAR SWIRL BURNER. THE PULVERIZED COAL IS FED TO THE BURNER THROAT BY AN ANNULAR FUEL GUN AND INJECTED CONCENTRICALLY TO THE BURNER AXIS.

THE FORMER SECONDARY AIR IS NOW SPLIT INTO TWO STREAMS: A REDUCED AIR FLOW WHICH IS PASSED AS USUAL THROUGH THE ANNULAR AIR COMPARTMENT SURROUNDING THE FUEL GUN, AND A TERTIARY AIR FLOW TO FOUR AIR NOZZLES WHICH ARE PLACED CONCENTRICALLY ABOUT THE BURNER QUARL EXIT. THE ADDITIVES, E.G. $CACO_3$ OR $Ca(OH)_2$, ARE INTRODUCED VIA NOZZLES LOCATED ON THE CENTERLINES OF THE TERTIARY AIR NOZZLES IN A MANNER TO PRODUCE AN ADDITIVE FILM AROUND THE FLAME. THE ADDITIVE NOZZLES ARE PLACED IN THE STAGING AIR COMPARTMENT, and ARE LOCATED CONCENTRICALLY ABOUT THE AXIS OF THE BURNER AT A DISTANCE TWICE THAT OF THE SECONDARY AIR COMPARTMENT OR EVEN LARGER. THE ADDITIVE LADEN STAGING AIR IS THUS MADE TO REACH THE FLAME ZONE, WHERE THE TEMPERATURES DO NOT REDUCE THE ACTIVITY OF THE ADDITIVES.

AT 100% COAL FIRING, THE CORE AIR DAMPER IS ALMOST CLOSED. IT IS ADJUSTED IN SUCH A WAY THAT JUST SUFFICIENT CORE AIR IS PASSED THROUGH THE CENTRAL COMPARTMENT TO AVOID RECIRCULATION FLOWS INDUCED BY THE SWIRLING SECONDARY AIR INTO THE CORE AIR COMPARTMENT

3.0 CONTROL OF NO_x EMISSIONS (CONT'D)

A VARIABLE SWIRL DEVICE ALLOWS A CONTROL OF THE SECONDARY AIR SWIRL INTENSITY.

THE TERTIARY AIR QUANTITY, CAN BE CONTROLLED BY THE BUTTERFLY VALVE IN THE TERTIARY AIR DUCT, WHICH ADJUSTS TERTIARY/SECONDARY AIR RATIO.

TO CONTROL THE OVERALL BURNER STOICHIOMETRY, THE TOTAL AIR FLOW TO EACH BURNER IS MEASURED INDIVIDUALLY.

AS A RESULT OF THE DISTRIBUTION IN AIR SUPPLY, THE FLAME, WHICH IS STABILIZED WITHIN THE BURNER MOUTH DUE TO THE PREVAILING AERODYNAMIC CONDITIONS, IS CHARACTERIZED BY TWO DISTINCT ZONES OF DIFFERENT STOICHIOMETRY; A FUEL - RICH PRIMARY ZONE AT THE BURNER EXIT, FOLLOWED BY A FUEL-LEAN SECONDARY OR BURN-OUT ZONE. THE DESIGN CONCEPT CAN THUS FULFILL THE LOW FUEL NO_x-FORMATION REQUIREMENT OF LOW OXYGEN CONCENTRATION IN THE FUEL PYROLYSIS ZONE OF THE FLAME AND ADDITIONALLY, BUT TO A LESSER DEGREE, REDUCE THE THERMAL NO_x FORMATION AS A CONSEQUENCE OF LOWERING THE MAXIMUM FLAME TEMPERATURES DUE TO INTERSTAGE COOLING AND AN INCREASE OF RECIRCULATED COMBUSTION GASES. FURTHERMORE THE BURNER CONCEPT ALLOWS THE ADDITION OF SORBENTS FOR SULPHUR CAPTURE IN SUCH A WAY THAT THE HIGHEST TEMPERATURE ZONES ARE AVOIDED AND YET THE REQUIRED INTENSE MIXING WITH THE COMBUSTION PRODUCTS IS ENSURED. OPTIMIZING THE

3.0 CONTROL OF NO_x EMISSIONS (CONT'D)

BURNER DESIGN AND CONTROL RESULTED IN PROVIDING LOW NO_x CONDITIONS WITHOUT SUBSTANTIAL LOSS OF COMBUSTION INTENSITY, TURN DOWN POTENTIAL OR BURN OUT PERFORMANCE.

THESE OBJECTIVES WERE REALIZED BY OPTIMIZATION OF:

- SHAPE, NUMBER AND OUTLET AREA OF STAGING AIR NOZZLES.
- CROSS-SECTION OF SECONDARY AIR FLOW.
- SWIRL INTENSITY OF SECONDARY AIR FLOW.
- FUEL INJECTION ANGLE AND VELOCITY, AND
- ANGLE AND LENGTH OF BURNER QUARL.

DOWNSTREAM OF THE PULVERIZED FUEL/AIR MIXTURE AND THE SECONDARY AIR, A SUB-STOICHIOMETRIC PRIMARY ZONE IS CREATED IN CLOSE VICINITY OF THE BURNER THROAT. OUR EXPERIMENTAL AND THEORETICAL INVESTIGATIONS HAVE CONFIRMED THAT THE AIR RATIO IN THAT REGION REPRESENTS THE SALIENT NO_x SENSITIVE PARAMETER.

BY VIRTUE OF THE DESCRIBED DESIGN FEATURES, IGNITION BECOMES INTENSE AND COMBUSTION SO RAPID THAT AN AIR DEFICIENCY OCCURS WHICH CAUSES A REDUCTION OF FUEL-LINKED NITROGEN COMPOUNDS TO MOLECULAR

3.0 CONTROL OF NO_x EMISSIONS (CONT'D)

NITROGEN. TO ENSURE COMPLETE COMBUSTION, STAGING AIR IN THE FORM OF A FEW SINGLE JETS IS INJECTED INTO THE BURN-OUT ZONE.

BY THE SINGLE-JET CONFIGURATION, SUFFICIENT MOMENTUM OF THE JETS IS RETAINED SO THAT EVEN AT SOME DISTANCE FROM THE BURNER THROAT, INTIMATE MIXING OF AIR WITH THE BURN-OUT ZONE IS AFFORDED AND NO SENSIBLE FLAME LENGTHENING WILL OCCUR.

IN VIEW OF THE FACT THAT THE PRIMARY ZONE REACTION PRODUCTS ALREADY RELEASE HEAT BEFORE BEING FINALLY BURNED OUT IN THE SECONDARY FLAME ZONE, THE FLAME TEMPERATURES IN THAT ZONE CAN BE EXPECTED TO BE LOWER THAN WITH UNSTAGED MIXING. IN ADDITION, THE OUTER RECIRCULATION OF FLUE GASES INTO THE FLAME, BY EXERTING A TEMPERATURE REDUCING EFFECT, WILL BE INTENSIFIED. THIS WILL NOT ONLY REDUCE FUEL NO_x FORMATION BUT ALSO THERMAL NO_x FORMATION.

THE MOMENTUM RATIO OF SECONDARY AIR TO PRIMARY AIR HAS BEEN SELECTED TO PROVIDE FOR A SATISFACTORY FLAME PATTERN. IN ADDITION TO INTERNAL FLUE GAS RECIRCULATION, FLUE GASES FROM THE POST-FLAME REGION ARE ENTRAINED BY THE FLAME. THE COMPOSITION OF THESE POST-FLAME GASES CORRESPOND TO THE SET MEAN EXCESS AIR; HENCE, ALL OF THE FURNACE WALLS INCLUDING THE BURNER ZONES, MAKE CONTACT ONLY WITH INERT FLUE GASES.

4.0 SO_x AND OTHER GASEOUS POLLUTANTS EMISSION CONTROL

4.1 THEORETICAL CONSIDERATIONS

THE RELEASE OF THE HEAT OF COMBUSTION LOCKED UP IN FOSSIL FUELS IS ALMOST EXCLUSIVELY ACCOMPLISHED BY COMBUSTION PROCESSES AT TEMPERATURES UP TO 2000°C. THE ENTHALPY CHEMICALLY BOUND WITHIN THE FUEL IS THEREBY TRANSFORMED INTO THE ENTHALPY OF THE PRODUCTS OF COMBUSTION.

WHEN COAL IS BURNED, THE PRODUCTS MAINLY CONSIST OF CARBON DIOXIDE, WATER VAPOUR, NITROGEN AND EXCESS OXYGEN, TOGETHER WITH THE POLLUTANTS NO_x, SO_x AND DUST. ONE CAN ASSUME WITH FAIR CERTAINTY THAT THE OXIDES OF NITROGEN AND SULPHUR ARE PRESENT IN THE FLUE GAS PREDOMINANTLY AS NO AND SO_2. THE AMOUNT OF NO_2 AND SO_3 ARE VERY SLIGHT.

IT IS KNOWN THAT THE FORMATION OF OXIDES OF NITROGEN CAN BE REDUCED BY AT LEAST 50% BY CAREFUL CONTROL OF COMBUSTION. BUT SINCE THE FORMATION OF SULPHUR DIOXIDE TAKES PLACE PARALLEL TO THAT OF CARBON DIOXIDE, THE ONLY WAY OF REMOVING THIS POLLUTANT FROM THE FLUE GASES TO REDUCE EMISSIONS IS BY CHEMICAL ABSORPTION.

WHEN $Ca(OH)_2$ OR $CaCO_3$ IS ADDED TO BIND THESE POLLUTANTS, THE ADDITIVES THEMSELVES ARE DEHYDRATED OR DECARBONATED (CALCINED) IN THE FURNACE.

4.0 SO_x AND OTHER POLLUTANTS EMISSION CONTROL (CONT'D)

4.2 PRACTICAL APPLICATION

THE STAGED MIXING BURNER (SM-BURNER) DEVELOPED BY STEINMUELLER TO REDUCE NO_x FORMATION OFFERS, COMPARED TO EARLIER CIRCULAR BURNERS, A BETTER WAY TO INJECT THE SORBENTS WITH THE STAGING AIR INTO THE FURNACE. WITH THE SM-BURNER THE THREE IMPORTANT CONDITIONS TO REDUCE THE SULPHUR AND OTHER POLLUTANT EMISSIONS CAN BE REALIZED. THESE ARE: PROPER TEMPERATURE, GOOD MIXING AND SUFFICIENT RESIDENCE TIME.

THE ADDITIVE DOES NOT PASS THROUGH THE HIGH TEMPERATURE FLAME ZONE, SO THAT SINTERING OF THE ADDITIVE CAN BE AVOIDED. DUE TO HIGH TURBULENCE AROUND THE FLAME THE MIXING OF THE ADDITIVE WITH THE FLUE GAS IS OPTIMUM. EVEN WITHOUT THE MIXING OF THE ADDITIVE WITH THE FUEL, ALMOST ALL THE RESIDENCE TIME FROM THE BURNER UP TO THE ESP IS AVAILABLE TO ABSORB THE POLLUTANTS.

5.0 PULVERIZED COAL SM-BURNER

THE PULVERIZED COAL/AIR MIXTURE WHICH LEAVES THE MILLS IN A CONDITION READY FOR IGNITION IS DELIVERED TO THE BURNERS THROUGH A PF SUPPLY PIPE WITH A REPLACEABLE ELBOW. IN THE DIVERGENT PF INLET, THE MIXTURE IS FORCED TO CHANGE DIRECTION. THE INCREASED CROSS-SECTIONAL AREA OF THE PF INLET AND THE SLOWING DOWN OF THE AIR FLOW PRODUCES BREAK UP AND AVOIDS ANY POSSIBLE AGGLOMERATION OF FUEL.

THE PF INLET NOZZLE, THE DIVERGENT PF INLET AND THE PF PIPE ARE MADE WEAR-RESISTANT.

AT THE BURNER DISCHARGE, THE FUEL/AIR MIXTURE IS FURTHER INTENSIVELY MIXED WITH THE SECONDARY AIR. ADEQUATE ARRANGEMENT OF THE BURNER OUTLET IS DESIGNED TO PROVIDE OPTIMUM FLOW CONDITIONS.

THE BURNER GUN ASSEMBLY IS LOCATED IN A WINDBOX SUBDIVIDED INTO A SECONDARY AIR SECTION AND A TERTIARY (STAGING) AIR SECTION THAT ALSO SUPPLIES THE CORE AIR WHICH IS ADMITTED TO THE GUN THROUGH A MANUALLY OPERATED DAMPER.

IN THE CENTER OF THE BURNER THE CORE AIR PIPE ALSO HOUSES THE OIL GUN.

THE ANNULAR PF DUCT LIES COAXIALLY AROUND THE CORE AIR PIPE ADJACENT TO THE BURNER MANTLE (SECONDARY AIR RING). THE MANTLE AIR PORTION CONSISTS OF A WIDE CYLINDRICAL TUBE AND THE CONICAL AIR INLET IN WHICH THE SWIRL VANE ASSEMBLY IS LOOSELY INSTALLED. THIS ASSEMBLY IS MADE UP OF A NUMBER OF

5.0 PULVERIZED COAL SM-BURNER (CONT'D)

VANES WELDED BETWEEN AN INNER GUIDE RING AND A CONICAL WALL RING WHICH FITS PRECISELY INTO THE CORRESPONDING PART OF THE WINDBOX. THE AIR SWIRLER CAN BE DISPLACED AXIALLY BY THREE ACTUATING RODS SYNCHRONIZED BY GEARING. WHEN THE SWIRLER MOVES AWAY FROM ITS CONICAL HOUSING, AN ANNULAR GAP IS LEFT AROUND IT THROUGH WHICH A PORTION OF THE SECONDARY AIR CAN THEN ENTER THE CYLINDRICAL SHELL WITHOUT SWIRL. THIS PARTIAL AIR FLOW MIXES WITH THE AIR FLOWING THROUGH THE SWIRL ASSEMBLY AND REDUCES THE SWIRL EFFECT AND THUS THE SWIRL ANGLE. THIS IN TURN AFFECTS THE FLAME CONFIGURATION. OBSERVATION WILL SHOW WHICH POSITION OF THE AIR SWIRLER GIVES THE MOST FAVOURABLE FLAME CONFIGURATION FOR A GIVEN FUEL.

A PRONOUNCED SWIRL WILL PRODUCE A SHORT AND BROAD FLAME, WHEREAS A SLIGHT SWIRL MAKES THE FLAME LONGER AND THINNER. WHEN SETTING UP THE FIRING SYSTEM AT CFB GAGETOWN, A MEAN VALUE FOR THE AIR SWIRL SETTING WAS WORKED OUT OVER THE COMPLETE FUEL RANGE AND THIS VALUE WAS THEN SET ON THE EQUIPMENT.

ON BURNER START-UP, THE RESPECTIVE ZONE AIR FLOW RATES WERE DETERMINED IN ORDER TO OBTAIN OPTIMUM STAGED COMBUSTION WITH A SUFFICIENTLY LOW NO_x AND SO_2 CONTENT.

6.0 ADDITIVE INJECTION SYSTEM

THE SCHEMATIC FIG. NO. 83150-A5 SHOWS THE CONSTRUCTION OF THE ADDITIVE TRANSPORT SYSTEM.

6.1 ADDITIVE STORAGE SYSTEM

THE ADDITIVE, $Ca(OH)_2$ OR $CaCO_3$, IS STORED IN A 85 m^3 STEEL SILO LOCATED ON THE CENTER LINE OF BOILER NO. 2. FILLING OF THE SILO BY TANK TRUCK IS ACCOMPLISHED VIA A PERMANENT SUPPLY LINE WHICH CONNECTS AN EXTERIOR COUPLING TO THE TOP OF THE SILO. THE NECESSARY TRANSPORT AIR IS GENERATED BY THE TRUCK MOUNTED COMPRESSOR.

AN ALARM IS PROVIDED AT THE TRUCK CONNECTION POINT TO INDICATE THAT THE MAXIMUM LEVEL OF THE SILO HAS BEEN REACHED. THE MAXIMUM LEVEL HAS BEEN SET SO THAT A RESIDUAL VOLUME OF 5 M^3 IS STILL AVAILABLE.

AERATION MODULES ARE FITTED IN THE BIN HOPPER SECTION FOR FLUIDIZING THE ADDITIVE SUPPLY DURING DOSING. THE OUTGOING AIR, NAMELY TRANSPORT AIR FROM THE TRUCK, FLUIDIZING AIR AND AIR FOR THE PNEUMATIC FEEDER, IS FILTER-CLEANED AND EXHAUSTED WITHIN THE BOILER HOUSE. THE FILTER ITSELF POSSESSES A MECHANICAL CLEANING SYSTEM WHICH IS AUTOMATICALLY ACTIVATED. TO PROTECT THE BIN AGAINST EXCESSIVE POSITIVE OR NEGATIVE PRESSURES THERE ARE FLAPS MOUNTED AT THE SILO ROOF.

6.0 ADDITIVE INJECTION SYSTEM (CONT'D)

6.2 ADDITIVE FEEDING

ADDITIVE FROM THE STORAGE BIN IS EXTRACTED BY A PNEUMATIC FEEDER TO A ROTARY VANE FEEDER WHICH IS ARRANGED FOR VARIABLE-SPEED CONTROL AS A FUNCTION OF BOILER LOAD. ADDITIONALLY, THE END SPEED OF THE ROTARY FEEDER IS CONTROLLED BY THE BULK FLOW SENSOR, WHICH TAKES ITS SIGNAL FROM THE COAL FEEDER AND PERMITS INFINITELY VARIABLE OPERATION THUS ALLOWING STOICHIOMETRIC OPERATION FROM 0 TO 4 CA/S MOLE RATIO.

BELOW THE ROTARY VANE FEEDER IS THE BULK FLOW SENSOR, (IMPACT PLATE) WHICH MEASURES THE BULK FLOW DELIVERED BY THE ROTARY FEEDER. THE IMPACT SCALE AMPLIFIER IS EQUIPPED WITH DIGITAL FLOW RATE AND TOTALIZER, WHICH ALLOWS THE CA/S MOLE RATIO AND SILO LEVEL TO BE DETERMINED.

DOWNSTREAM OF THE BULK FLOW SENSOR, THE ADDITIVE IS ENTRAINED BY THE EJECTOR, WHICH DELIVERS IT VIA A CONVEYING PIPE TO A DISTRIBUTOR VALVE WHERE THE ADDITIVE AIR MIXTURE IS DIVIDED INTO EIGHT UNIFORM FEED LINES. FOUR FEED LINES ARE PROVIDED TO EACH BURNER, AND EACH OF THESE CAN BE ISOLATED BY BLANKING VALVES.

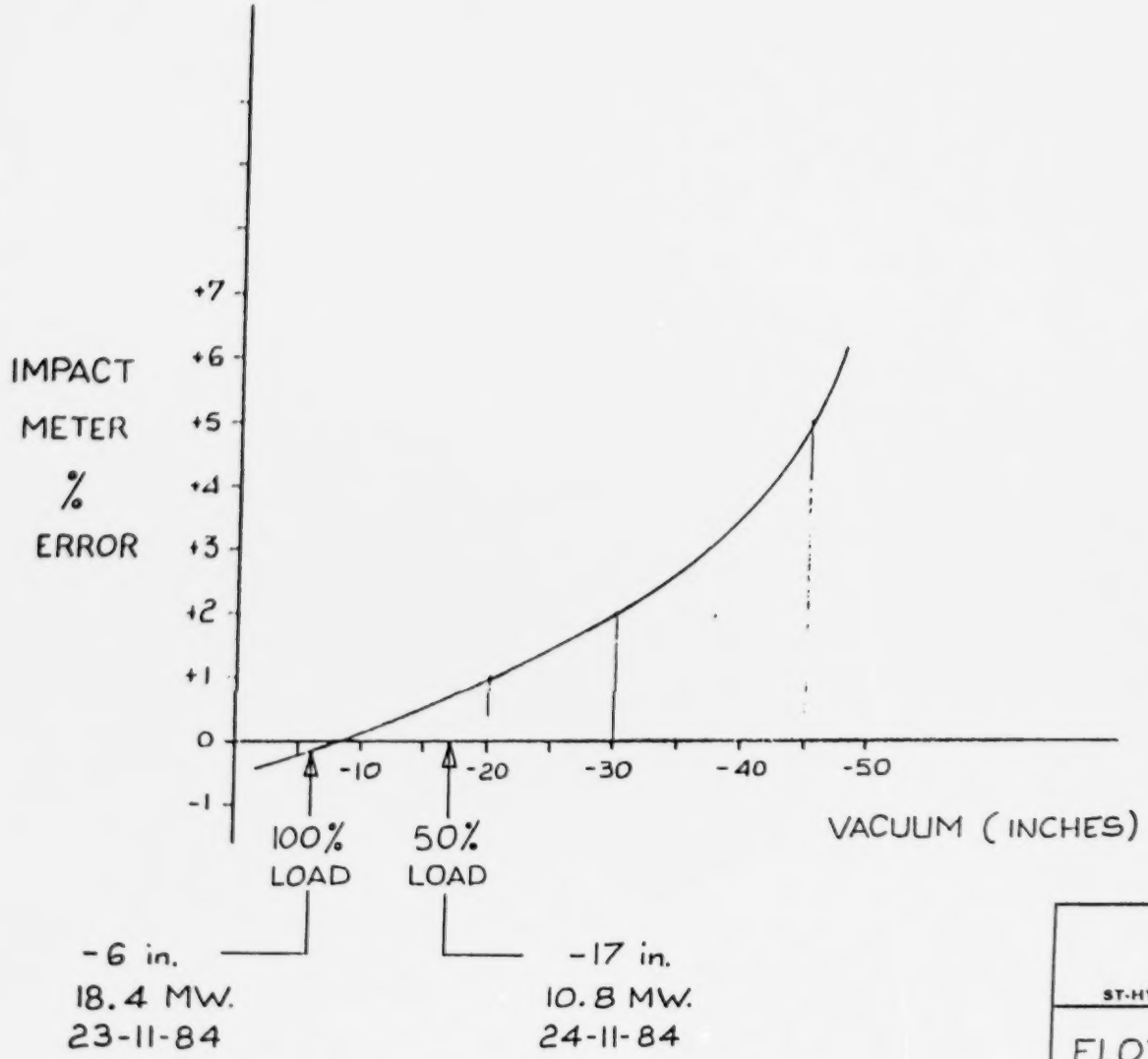
6.0 ADDITIVE INJECTION SYSTEM (CONT'D)

6.3 AIR SUPPLY

THE REQUIRED AIR SUPPLY IS GENERATED BY TWO ROTARY COMPRESSORS WHICH ARE SOUNDPROOFED AND EQUIPPED WITH HIGH EFFICIENCY MOTORS. ONE OF THE COMPRESSORS DELIVERS AIR FOR THE BIN FLUIDIZATION SYSTEM AND THE PNEUMATIC FEEDER, WHILST THE OTHER COMPRESSOR IS OPERATED AT AN APPROPRIATELY HIGHER DISCHARGE PRESSURE TO SERVE THE ADDITIVE CONVEYING SYSTEM.

AIR FOR ADDITIVE CONVEYING IS METERED AND INDICATED BY GAUGE DISPLAY. A SECOND AIR CONNECTION POINT IS PROVIDED TO ALLOW THE SYSTEM TO BE CONNECTED TO EXISTING PLANT AIR SYSTEM IN THE EVENT THE COMPRESSOR SHOULD BECOME DEFECTIVE.

THE ERROR IN IMPACT METER READING DUE TO THE CHANGE IN VACUUM AT THE EJECTOR' IS LESS THAN 2% BETWEEN 50% AND 100% LOAD ON THE BOILER AS SHOWN ON THE NEXT PAGE.



GAGETOWN

C-83150

VOLCANO INC.

ST-HYACINTHE MONTREAL

FLOWMETER % ERROR.

	DRAWN	TRACED	CHECKED	APP'D	APP'D
BY					
DATE					

7.0 MANUFACTURE AND INSTALLATION OF EQUIPMENT

ENERGY, MINES AND RESOURCES CANADA VIA SUPPLY AND SERVICES CANADA AWARDED A CONTRACT TO VOLCANO INC. TO UNDERTAKE THE DEVELOPMENT, DETAILED DESIGN, MANUFACTURE AND INSTALLATION OF TWO (2) SM-BURNERS, AT CFB GAGETOWN.

PRIOR TO BEING AWARDED THE BURNER RETROFIT CONTRACT, VOLCANO INC. SUCCESSFULLY COMPLETED A CONCEPTUAL DESIGN STUDY OF THE BOILER CONVERSION.

PARTICIPATING GROUPS AND THEIR RESPONSIBILITIES FOR THIS PROJECT:

L & C STEINMUELLER GMBH (WEST GERMANY) WERE RESPONSIBLE FOR THE DESIGN OF THE RETROFIT AS FOLLOWS:

COMPONENTS REQUIRED FOR MODIFIED INSTALLATION:

1- BURNER TUBE NEST
2- STAGED MIXING BURNERS
3- COMBUSTION AIR DUCT FROM TUBULAR AIR HEATER TO NEW BURNERS
4- SECONDARY AND TERTIARY AIR DUCTS
5- PRIMARY AIR DUCTS
6- PULVERIZED FUEL PIPING FROM EXHAUSTERS TO BURNERS
7- REFRACTORY
8- INSULATION
9- AIR FLOW MEASURING DEVICES

7.0 MANUFACTURE AND INSTALLATION OF EQUIPMENT (CONT'D)

10- DAMPERS
11- EXPANSION JOINTS
12- ADDITIVE SILO
13- ADDITIVE INJECTION SYSTEM
14- COMBUSTION CONTROL DESIGN PHILOSOPHY

VOLCANO INC. WERE RESPONSIBLE FOR THE MANUFACTURE, SUPPLY AND INSTALLATION OF THE CONVERSIONS AS FOLLOWS:

1- MANUFACTURE COMPONENTS AS INDICATED ABOVE
2- COMBUSTION CONTROLS
3- FLAME SAFEGUARD SYSTEM
4- CIVIL WORK
5- STRUCTURAL STEEL MODIFICATIONS
6- MATERIAL PROCUREMENT
7- NEW OIL TRAIN ASSEMBLY
8- OIL PUMPSET
9- SILO SUPPORT STEEL
10- INSTRUCTION MANUALS

INSTALLATION ACTIVITIES:

1- REMOVAL OF EXISTING BURNERS
2- REMOVAL OF REFRACTORY AT BURNER THROAT
3- REMOVAL OF EXISTING BURNER TUBE NEST
4- REMOVAL OF REDUNDANT COMBUSTION AIR DUCT
5- REMOVAL OF PRIMARY AIR DUCT
6- REMOVAL OF P.F. PIPING
7- REMOVAL OF PARTIAL FRONT WALL CASING AND BRICKS IN THE VICINITY OF THE BURNERS

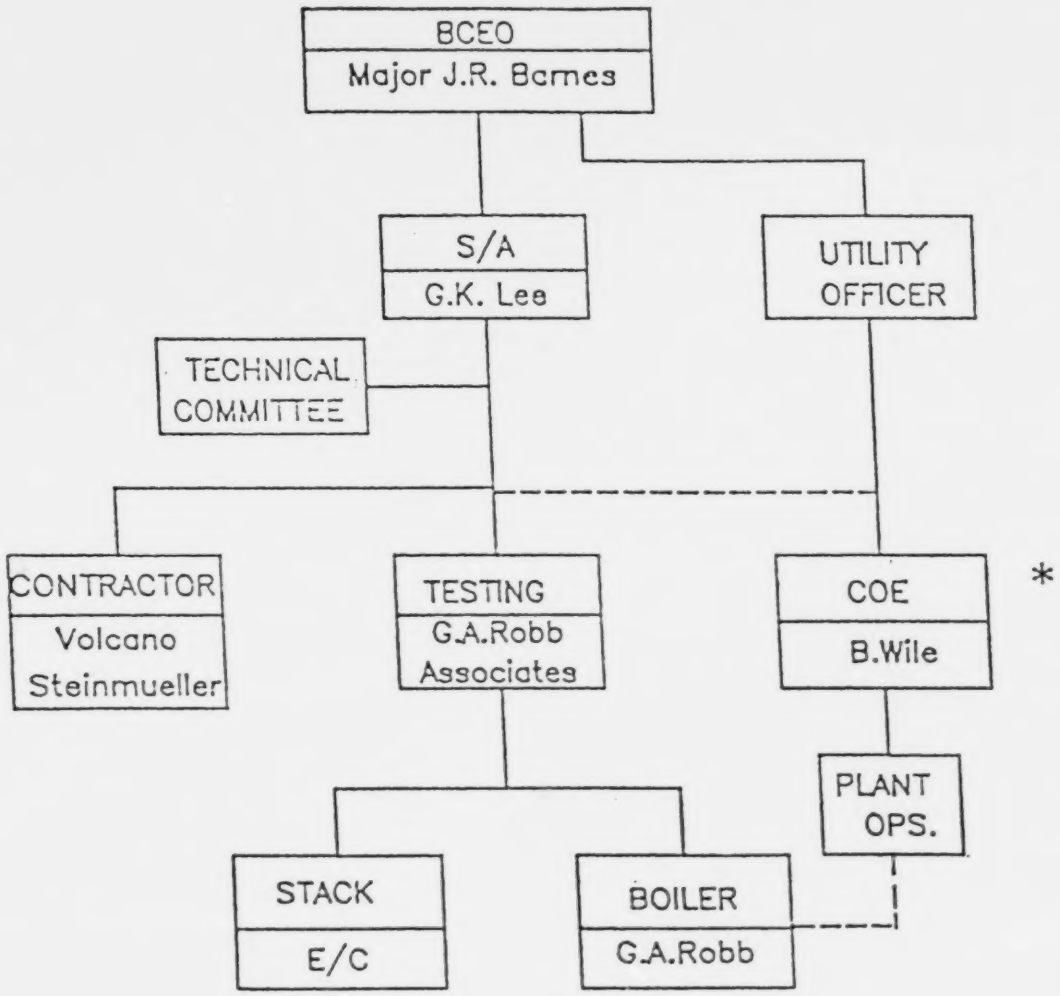
7.0 MANUFACTURE AND INSTALLATION OF EQUIPMENT (CONT'D)

8- INSTALLATION OF NEW DUCTWORK
9- INSTALLATION OF NEW BURNER TUBE NEST
10- INSTALLATION OF NEW BURNERS ALONG WITH BURNER MOUNTING PLATE
11- INSTALLATION OF NEW BURNER QUARL
12- INSTALLATION OF OIL GUN ASSEMBLIES IN THE CORE PIPE
13- ALIGNMENT OF OIL GUN ASSEMBLIES IN-SITU
14- INSTALLATION OF PROPANE GAS IGNITOR TRAIN
15- INSTALLATION OF OIL TRAINS (WIDE RANGE MECHANICAL)
16- INSTALLATION OF NEW OIL PUMPS
17- INSTALLATION OF ADDITIVE SYSTEM
18- INSTALLATION OF I.R. & U.V. SCANNERS
19- INSTALLATION OF INSTRUMENT AIR PIPING
20- INSTALLATION OF SCANNER AIR PIPING.

CFB GAGETOWN CENTRAL HEATING PLANT PERSONNEL WERE RESPONSIBLE FOR PROVIDING STORAGE SPACE, ACCESS TO UNIT NO. 2 AND BOILER AND AUXILIARY EQUIPMENT CONDITION REPORT, PRIOR TO DELIVER SAME TO VOLCANO FOR CONVERSION.

THE MANAGEMENT STRUCTURE FOR THE PROJECT IS SHOWN ON THE NEXT PAGE.

CFB GAGETOWN LOW NOX AND SOX BURNER RETROFIT MANAGEMENT CHART – TESTING PROGRAM



* Note: For the duration of testing, the Chief Operating Engineer must be recognized as the authority in all aspects of the tests that may affect the operation of the plant.

M.McDonald
26 Oct 1994

8.0 NO_x AND SO_x BURNER TESTING PROGRAMME

8.1 OBJECTIVE

BASELINE TESTS WERE CONDUCTED FROM 26.03.82 TO 30.03.82 TO PROVIDE DATA ON EMISSION LEVELS WITH EXISTING EQUIPMENT FOR COMPARISON WITH LEVELS MEASURED AFTER THE NEW EQUIPMENT HAD BEEN INSTALLED. VOLCANO WAS ASKED TO GUARANTEE SPECIFIED REDUCTIONS AS COMPARED WITH THE BASELINE TESTS WITHOUT LOSS OF EFFICIENCY. THE EMISSION MEASUREMENTS WERE MADE BY THE POLLUTION MEASUREMENT DIVISION OF THE AIR POLLUTION CONTROL DIRECTORATE OF ENVIRONMENT CANADA.

8.2 SUMMARY OF TEST RESULTS

BASELINE TESTS WERE CARRIED OUT AT NOMINAL BOILER LOADS OF 50% AND 100% USING COAL ONLY AND COAL BLENDED WITH LIMESTONE. OIL STABILIZATION OF THE COAL FLAMES WAS USED DURING ALL TESTS FOR SAFETY REASONS.

THE COAL AND LIMESTONE ANALYSIS AND HIGHLIGHTS OF THE TEST RESULTS ARE GIVEN IN THE FOLLOWING PAGES. MORE DETAILED INFORMATION ON THE TESTS, ABSTRACTED FROM REPORTS BY G.A. ROBB ASSOCIATES AND ENVIRONMENT CANADA ARE GIVEN IN SECTION 12.

8.0 NO_x AND SO_x BASELINE TESTS (CONT'D)

COAL ANALYSIS (AS FIRED AVERAGE MARCH 26, 29, 1982)

COAL ULTIMATE ANALYSIS

CARBON	0.764
HYDROGEN	0.049
SULPHUR	0.026
NITROGEN	0.014
ASH	0.085
OXYGEN (by dif)	0.063
	1.000

PROXIMATE ANALYSIS % BY WEIGHT	
MOISTURE	1.5
ASH	8.5
VOLATILE	32.2

SULPHUR FORMS	
SULPHATE	0.3
PYRITE	1.6
ORGANIC (dif)	0.6

ASH ANALYSIS % BY WEIGHT	
Si02	28.9
A1203	15.9
Fe203	32.8
Ti02d	0.8
P205	0.3
CaO	1.5
MgO	0.7
SO3	17.3
Na20	0.3
K2O	1.6

ASH FUSION TEMP. C	OXIDIZING	REDUCING
INITIAL	1345	1080
SPERICAL	1390	1175
HEMISPHERICAL	1400	1260
FLUID	1410	1330

HIGHER HEATING VALUE 33,266 KJ/Kg
HARDGROVE GRINDABILITY 59

SCREEN ANALYSIS, % BY WT

+ 1 1/2	0.4	3/4 x 1/2	11.0
1 1/2 x 1	4.0	1/2 x 1/4	22.0
1 x 3/4	6.0	1/4 x 1/8	25.0

NOTE: ANALYSIS BY CANMET.

8.0 NO_x AND SO_x BASELINE TESTS (CONT'D)

LIMESTONE ANALYSIS (AVERAGE OF 2 SAMPLES MARCH 29 AND 31)

LIMESTONE SOURCE - HAVELOCK N.B.

MOISTURE <0.1% BY WEIGHT

ANALYSIS	% BY WEIGHT	SCREEN ANALYSIS	% BY WEIGHT
SIO2	1.8	+1/4	<.1
AL203	0.2	1/4 x 6	0.1
Fe203	0.4	6 x 12	28.0
Ti02	0.2	12 x 20	64.2
P205	0.1	20 x 60	64.2
CaO	53.6	69 x 0	6.1
MgO	<.1		
SO3	0.5		
Na20	<.1		
K20	0.1		
LOF	43.0		

NOTE: ANALYSIS BY THE CANADIAN CENTRE FOR MINERAL AND ENERGY TEHCNOLOGY (CANMET).

8.0 NO_x AND SO_x BASELINE TESTS (CONT'D)

DATE 1982	LOAD MW	UNIT NO.	O_2 %	NO_x * PPM	SO_2* PPM	Ca/S MOL
26.3	20	2	3.6	480	1920	Ø
27.3	9	2	4.0	370	1930	Ø
28.3	20.6	3	6.0	590	1970	Ø
28.3	10.5	3	6.2	420	1990	Ø
29.3	18.6	3	6.5	720	1280	3.25
29.3	8.5	3	7.2	420	1200	3.25

* BASED ON 3% O_2 IN FLUE GAS

8.0 NO_x AND SO_x BASELINE TESTS (CONT'D)

GAGETOWN TEST

March 28, 1982
Morning, Full Load
Unit 3, No Limestone

SAMPLE: I.D.: A419-82 (Bottom Ash), A420-82 (Fly Ash)

ULTIMATE ANALYSIS	BOTTOM ASH	FLY ASH *
Component	%	%
SiO_2	20.92	22.85
AL_2O_3	10.90	11.94
Fe_2O_3	55.45	38.52
TiO_2	0.43	0.45
P_2O_5	0.17	0.18
CaO	1.14	1.13
MgO	0.76	0.49
SO_3	3.41	1.25
Na_2O	----	----
K_2O	0.89	1.10
BaO	0.16	0.14
SrO	----	----
Mn_3O_4	----	----
LOF	6.25	21.96

ASH FUSIBILITY (BOTTOM ASH only)

	OXIDIZING		REDUCING	
	F	(C)	F	(C)
INITAL DEFORMATION	2590	(1421)	2035	(1113)
SOFTENING-SPERICAL	2600	(1427)	2050	(1121)
SOFTENING-HEMISPHERICAL	2605	(1429)	2055	(1124)
FLUID	2620	(1438)	2070	(1132)

* The fly ash was collected from the cyclone hopper.

NOTE: ANALYSIS BY CANMET.

9.0 COMMISSIONING AND ACCEPTANCE TESTS

9.1 TIME SCHEDULE

COMMISSIONING AND ACCEPTANCE TESTS WERE CARRIED OUT IN THREE STAGES, DESIGNATED IN THIS REPORT AS TEST SERIES 1, 2 AND 3 WHICH WERE CONDUCTED FROM 23.11.1984 TO 28.11.1984, 22.03.1985 TO 28.03.1985 AND 25.11.1985 TO 03.12.1985 RESPECTIVELY.

9.2 TEST SERIES 1.

9.2.1 TEST PROCEDURE.

COMMISSIONING OF THE LIGHT FUEL OIL AND P.F. FIRING TOOK PLACE IN THE PERIOD FROM 25.10.1984 TO 22.11.1984. THE TEST COAL (SULPHUR CONTENT 2.8%) WAS AVAILABLE FROM 20.11.1984. THE ACCEPTANCE TESTS WERE CARRIED OUT FROM 23.11.1984 TO 28.11.1984.

CALIBRATION AND CONTINUOUS MONITORING OF NO_x, SO_2, CO AND O_2 BY ENVIRONMENT CANADA WERE STARTED SEVERAL HOURS BEFORE THE START OF THE TEST DAY. THE BOILER LOAD WAS SET AT THE REQUIRED LOAD WITH NORMAL EXCESS AIR.

IN ADDITION TO MONITORING GASEOUS EMISSIONS, ENVIRONMENT CANADA COLLECTED PARTICULATE SAMPLES FROM THEIR MONITORING POINTS BEFORE THE STACK PLENUM. THESE WERE USED TO DETERMINE COMBUSTIBLES IN THE DUST AT THE SAMPLING POINT.

9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

THE ENVIRONMENT CANADA SAMPLING POINT WAS DOWNSTREAM OF A MECHANICAL DUST COLLECTOR BUT UPSTREAM THE STACK.

SUBSTANTIAL AMOUNTS OF PARTICULATE ARE REMOVED BY THE MECHANICAL COLLECTOR BEFORE THE SAMPLING POINT AND BY THE PLENUM CHAMBER WHICH IS AFTER THE SAMPLING POINT BUT BEFORE THE STACK SO THAT THE PARTICULATE LOADING AT THE ENVIRONMENT CANADA SAMPLING POINT IS LESS THAN THAT LEAVING THE BOILER AND MORE THAN THAT IN THE STACK. THUS THESE SAMPLES ARE NOT DIRECTLY INDICATIVE OF EITHER STACK PARTICULATE EMISSIONS OR THE QUANTITY OF PARTICULATES LEAVING THE BOILER.

THE PARTICULATE MEASUREMENTS BY ENVIRONMENT CANADA ALSO PROVIDED THE FLOW RATE OF GASEOUS EMISSIONS IN PPM/HOUR. PARTICULATE EMISSIONS ARE PROVIDED IN MASS UNITS PER HOUR.

THE ANALYSIS OF THE PARTICULATES COLLECTED AT THE ENVIRONMENT CANADA SAMPLING POINT MAY DIFFER FROM THAT OF PARTICULATES TAKEN FROM THE DUST COLLECTOR HOPPERS. THE MATERIAL PASSING THROUGH THE MECHANICAL COLLECTORS WILL BE LIGHTER THAN THE MATERIAL FROM THE HOPPERS.

ABOUT 15 MINUTES BEFORE THE BEGINNING OF EACH TEST ALL HOPPERS WERE EMPTIED AND SOOT BLOWERS WERE OPERATED. G.A. ROBB ASSOCIATES ENSURED THAT

9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

TEMPERATURE AND OXYGEN READINGS WERE TAKEN AT THE AIR HEATER OUTLET. ANY DIFFERENCE BETWEEN PLANTS RECORDERS ON THE PANEL, AND INSTRUMENTS USED FOR THE TEST, WERE NOTED.

DURING EACH TEST, G.A. ROBB ASSOCIATES COLLECTED COAL SAMPLES AT THE PULVERIZER INLET. DURING FULL LOAD TESTS WITH 2 PULVERIZERS, ONE SAMPLE WAS TAKEN EVERY 15 MINUTES FROM THE ALTERNATE PULVERIZER. THE SAMPLES WERE TAKEN FROM THE PULVERIZER DISCHARGE USING A SMALL PROBE AND STORED IN PLASTIC BAGS IN METAL CONTAINERS.

IN ADDITION, G.A. ROBB ASSOCIATES RECORDED PANEL DATA PLUS THE TEMPERATURE AND OXYGEN READINGS AT THE AIR PREHEATER OUTLET. READINGS WERE MADE AT 15 MINUTES INTERVALS. PHOTOCOPIES OF RECORDER CHARTS WERE RETAINED.

THE FOLLOWING READINGS WERE RECORDED BY G.A. ROBB ASSOCIATES:

BOILER LOAD	MW (THERMAL)
BOILER WATER	OUTLET PRESSURE
	OUTLET TEMPERATURE
	INLET TEMPERATURE
	% FLOW

9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

COMBUSTION AIR TEMPERATURE
- OUTDOOR
- AMBIENT (ROOM)
- AIR HEATER IN
- AIR HEATER OUT
- PRIMARY AIR LOWER BURNER
- PRIMARY AIR UPPER BURNER

COMBUSTION AIR FLOW % OF FULL RATE

GAS TEMPERATURE
- AIR HEATER IN
- AIR HEATER OUT (PANEL)
- AIR HEATER OUT (PORTABLE)

O_2 AIR HEATER OUTLET
- PANEL
- PORTABLE

PULVERIZER LOAD
- AMPS - LOWER BURNER MILL
- AMPS - UPPER BURNER MILL

PULVERIZER DRAFT

WINDBOX PRESSURE

FURNACE DRAFT

LIMESTONE FLOW RATE

FOR TESTS WITH LIMESTONE, G.A. ROBB ASSOCIATES OBTAINED LIMESTONE SAMPLES FROM THE VERTICAL CHUTE SAMPLING CONNECTION EVERY 15 MINUTES. THESE SAMPLES WERE PLACED IN A PLASTIC BAG INSIDE A PAIL.

ABOUT 15 MINUTES BEFORE THE END OF EACH TEST, G.A. ROBB ASSOCIATES COLLECTED ASH SAMPLES FROM THE COLLECTOR HOPPERS AND THE FURNACE BOTTOM. THESE WERE PLACED IN BUCKETS UNTIL COOL, THEN TRANSFERRED TO PLASTIC BAGS AND PUT IN CONTAINERS.

9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

VOLCANO/STEINMUELLER WERE RESPONSIBLE FOR THE PROVISION OF AN ACCURATE MEASUREMENT OF ADDITIVE FEEDRATE, AS WELL AS MEETING CONTRACT PERFORMANCE REQUIREMENTS.

DETAILS OF THE TEST PROCEDURES USED BY G.A. ROBB ASSOCIATES AND ENVIRONMENT CANADA ARE GIVEN IN SECTION 13.

9.2.2 CALIBRATION OF SORBENT FLOW METER

DURING CALIBRATION OF THE IMPACT FLOWMETER, IT WAS DISCOVERED THAT THE FEED CHUTE UNDER THE ROTARY FEEDER WAS GROSSLY OVERSIZED AND WITH THE ROTARY FEEDER AT 90° TO THE IMPACT PLATE, THE MATERIAL FLOW WAS USUALLY ALL AT ONE SIDE, (OUTER) AND AS EACH ROTARY FEED "POCKET" DROPPED OUT, THE DISCHARGED MATERIAL WOULD BUILD-UP ON THE IMPACT PLATE IN A RANDOM WAY, GIVING ERRONEOUS READINGS.

IN ORDER TO RECTIFY THIS PROBLEM, THE FEED CHUTE WAS REDUCED TO ABOUT 7 SQ. INCHES AND THE CHUTE MADE FROM A ROUND 6" PLASTIC PIPE. A BAFFLE WAS INSTALLED AT THE HEAD END OF THE ORIGINAL CHUTE TO FORCE ALL MATERIAL INTO THE NEW CHUTE WHICH NOW DISCHARGES ONTO THE UPPER END OF THE IMPACT PLATE.

AFTER THE MODIFICATIONS WERE MADE TO THE FEED CHUTE, THE UNIT WAS RE-CALIBRATED WITHOUT DIFFICULTY AT ATMOSPHERIC PRESSURE AND THE SAMPLES CAUGHT IN A DRUM UNDER THE IMPACT PLATE HOUSING. REPEATABILITY WAS ALSO GOOD UNDER THIS CONDITION.

9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

HOWEVER, UNDER DIFFERENT AMOUNTS OF VACUUM, THE MEASUREMENT WAS AFFECTED AND CAUSED THE SCALE TO INDICATE MORE WEIGHT THAN ACTUAL. THESE FIGURES WERE: AT - 5 IN.W.C. THE EFFECT WAS 0%, AT - 20 IN.W.C. THE EFFECT WAS - 1% AND AT - 40 IN.W.C. THE EFFECT WAS -5%. REFER TO GRAPH PAGE 6.4 FOR IMPACT METER PERCENTAGE ERROR.

THE SYSTEM WAS RE-CALIBRATED AGAIN AT ATMOSPHERIC PRESSURE INTO A DRUM. THIS TEST WAS + 1.1% AND THE THIRD TEST WAS - 0.64%. THE SYSTEM WAS CONSIDERED SATISFACTORY AT THE FOLLOWING SETTINGS:

ZERO, COARSE	- 7
FINE	- 491
SPAN, COARSE	- 2
FINE	- 370

9.2.3 RECOMMENDATIONS FOR FLOW METER MODIFICATIONS

A ROTARY AIR LOCK SHOULD BE INSTALLED BETWEEN THE BOTTOM OF THE IMPACT PLATE HOUSING AND THE EJECTOR. THEN THE SYSTEM COULD BE TAKEN TO ATMOSPHERIC PRESSURE. THIS WOULD ELIMINATE THE PROBLEMS OF

9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

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9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

VARIABLE VACUUM PRESSURES THAT ARE DEVELOPED AT THE EJECTOR NOZZLE FROM AFFECTING THE FLOW METER. ALSO, IF TWO OR MORE ADDITIVES ARE TO BE RUN, THEN THE INSTALLATION OF A MULTI-SPAN BOARD IS RECOMMENDED SO THAT THE UNIT CAN BE CALIBRATED FOR EACH ADDITIVE SELECTED WITHOUT TOUCHING THE CALIBRATING SPAN ADJUSTMENTS ONCE SET.

ADD SHORT SECTION IN PIPE ABOVE ROTARY FEEDER FOR INSTALLATION OF "HIGH" AND "LOW" LEVEL CONTROL DEVICE.

THE VERTICAL STORAGE CHUTE BETWEEN PNEUMATIC FEEDER AND ROTARY FEEDER SHOULD BE FITTED WITH HIGH AND LOW LEVEL SWITCHES, WHICH WOULD OPEN AND CLOSE THE FLOW CONTROL VALVE AS THE LEVEL DICTATES.

AS A TEMPORARY MEASURE FOR TESTING PURPOSES A LARGE OPENING WITH A MANUALLY OPERATED CONTROL VALVE AND VACUUM GAUGE WAS INSTALLED IN ORDER TO CONTROL AND MAINTAIN THE VACUUM AT APPROXIMATELY - 2 IN.W.C.

9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

9.2.4 SUMMARY OF TEST RESULTS

BEFORE TEST SERIES 1 BEGAN, i.e. IN THE TIME FROM 20.11.1984 TO 22.11.1984, THE BURNERS WERE OPERATED WITH THE TEST COAL, OPTIMISED AND ADJUSTED TO SUIT FURNACE CONDITIONS. AS A RESULT, THE DISTRIBUTION OF PRIMARY, SECONDARY AND TERTIARY AIRFLOWS DIFFERED FROM THE ORIGINAL DESIGN. THE MAXIMUM ATTAINABLE LOAD IN EACH CASE DEPENDED ON THE HEATING OUTPUT REQUIRED, i.e. ON THE TIME OF DAY AND THE OUTSIDE TEMPERATURE. DURING THE TESTS AT FULL LOAD BOILER NO. 2 TOOK OVER THE FULL PLANT LOAD IN EACH CASE, BUT THE ENVISAGED BOILER CAPACITY OF 20.5 MW WAS NEVER ATTAINED. LIMESTONE WITH A $CaCO_3$CONTENT OF APPROX. 90% WAS INJECTED AS THE ADDITIVE. SLAKED LIME WAS NOT TESTED.

TO ENSURE A STABLE P.F. FLAME UNDER THE FURNACE CONDITIONS OBTAINING IN THE HOT WATER BOILER, THE PRIMARY AIR FACTOR WAS NOT ALLOWED TO DROP BELOW ABOUT $n_p = 1$.

9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

ALTHOUGH P.F. FLAMES WERE OBTAINED WITHOUT OIL BACKUP FIRING, AT THE OPERATOR'S WISH A MINIMUM OIL THROUGHPUT OF APPROX. 50 L/HR PER BURNER WAS SET IN EACH CASE.

BEFORE A TEST COMMENCED THE SOOTBLOWERS WERE OPERATED.

THE FOLLOWING FIVE PAGES GIVE TEST SERIES 1 DATA ON:

- COAL ANALYSIS
- BOILER PERFORMANCE
- AIR FLOWS CORRECTED FOR TEMPERATURE AND PRESSURE
- FLUE GAS ANALYSIS FROM AVERAGING ENVIRONMENT CANADA DATE (THEY ARE NOT AN EXACT AVERAGE OF CONTINUOUS MEASUREMENTS)
- CALCULATED DEGREE OF DESULPHURIZATION
- NO_x REDUCTION BASED ON A REFERENCE VALUE OF 673 PPM

THE LIMESTONE ANALYSIS ARE GIVEN IN SECTION 8 AND DETAILED DATA SHEETS ARE GIVEN IN SECTION 13.

9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

DURING THE FULL LOAD TESTS, NO. 1 AND NO. 2, BOTH WITH AND WITHOUT LIMESTONE INJECTION AND USING THE TEST COAL, A MAXIMUM BOILER OUTPUT OF ONLY 18 MW WAS ACHIEVED (TOTAL HEATING REQUIREMENT).

TEST SERIES 1
CFB GAGETOWN

DATE: 12.12.84

SHEET 6

DATE	TEST RUN NO.	DESCRIPTION
23.11.84	1	100% LOAD WITHOUT LIMESTONE INJECTION WITH TEST COAL
23.11.84	2	100% LOAD WITH LIMESTONE INJECTION WITH TEST COAL
24.11.84	3	50% LOAD WITHOUT LIMESTONE INJECTION WITH TEST COAL
25.11.84	4	50% LOAD WITH LIMESTONE INJECTION WITH TEST COAL
26.11.84	5	100% LOAD WITHOUT LIMESTONE INJECTION WITH LOW SULPHUR COAL
26.11.84	6	100% LOAD WITH LIMESTONE INJECTION WITH LOW SULPHUR COAL
27.11.84	7	100% LOAD OLD BOILER NO. 1 WITH TEST COAL
27.11.84	8	50% LOAD OLD BOILER NO. 1 WITH TEST COAL
28.11.84	9	100% LOAD WITH LIMESTONE INJECTION WITH TEST COAL

COAL ANALYSIS (AS FIRED)

	AS REC'D	DRY
PROXIMATE ANALYSIS		
MOISTURE	1.45	
ASH	6.86	6.96
VOLATILE	36.67	37.21
FIXED CARBON (BY DIFFERENCE)	55.02	35.33
ULTIMATE ANALYSIS		
CARBON	75.15	76.26
HYDROGEN	5.04	5.11
SULPHUR	3.48	3.53
NITROGEN	1.57	1.59
ASH	6.86	6.96
OXYGEN (BY DIFFERENCE)	6.45	6.55
HEAT VALUE		
CAL/GM	7599	7711
KCAL/KG	7599	7711
MF/KG	31.82	32.28
BTU/LB	13678	13879
FREE SWELLING INDEX	6 1/2	6 1/2

ASH FUSIBILITY	OXIDIZING		REDUCING	
	°F	(°C)	°F	(°C)
INITIAL DEFORMATION	2555	(1402)	1995	(1091)
SOFTENING-SPHERICAL	2620	(1488)	2080	(1138)
SOFTENING-HEMISPHERICAL	2625	(1441)	2375	(1302)
FLUID	2635	(1446)	2440	(1338)

* ANALYSIS BY CANMET

DATE	LOAD MW UNIT 2	START	FINISH	DURATION	NOTES
FRIDAY Nov. 23/84	17.5	11.30	16.00	4.5	FULL LOAD, NO LIMESTONE INJECTION: SO_x: 2450 PPM, NO_x: 280 PPM. MIN. OIL
	18.5	20.45	24.00	3.25	FULL LOAD, LIMESTONE INJECTION AT CA/S RATIO OF 2.5/1; APPROX. SO_2 LEVEL WAS SET AT 50% BY CHANGING THE LIMESTONE INJECTION RATE. MIN. OIL
SATURDAY Nov. 24/84	10	16.30	20.30	4	50% LOAD, NO LIMESTONE INJECTION SO_x: 2600 PPM, NO_x: 250 PPM CO; 200 PPM. MIN. OIL
SUNDAY Nov. 25/84	10	11.00	16.00	5	50% LOAD, LIMESTONE INJECTION AT CA/S RATIO OF 2.5/1; SO_x DROPPED SLOWLY FROM 2600 PPM TO 1450 PPM AND EVENTUALLY TO 1310 PPM. MIN. OIL
MONDAY Nov. 26/84	17.5	12.00	15.30	3.5	FULL LOAD TEST, NO LIMESTONE INJECTION; BASE WINTER COAL SO_x: 1070 PPM, NO_x: 260 PPM. MIN. OIL
	17.0	15.30	17.00	1.5	LIMESTONE INJECTION AT CA/S RATIO 2.5/1; SO_x: 800 PPM - 650 PPM
Short tests	17.0	17.00	17.45	0.75	LIMESTONE INJECTION CUT TO CA/S RATIO OF 1.5/1, SO: 800 PPM
	17.0	17.45	18.15	0.5	LIMESTONE INJECTION AT CA/S RATIO OF 3.5/1 SO_x: 550 PPM

ATE	LOAD MW	START	FINISH	DURATION	NOTES
	UNIT 2				
	UNIT 1				
TUESDAY NOV 27/84	17.5	10.00	15.00	5.0	FULL LOAD ON TEST COAL, NO LIMESTONE INJECTION; SO_x: 2100 PPM, NO_x: 700 PPM
	10	15.00	16.30	1.5	50% LOAD TEST, NO LIMESTONE INJECTION; SO_x: 1900 PPM, NO_x: 450 PPM
	UNIT 2				
WEDNESDAY Nov. 28/84	16.5	11.00	12.00	1.0	FULL LOAD, TEST COAL, LIMESTONE INJECTION AT CA/S RATIO OF 2.5/1; SO_x REDUCTION 45%
		12.00	14.15	2.25	LIMESTONE INJECTION RATE INCREASED TO GIVE 50% SO_x REDUCTION

MEASURED VALUES AND FLUE GAS ANALYSIS
CFB GAGETOWN

DATE: 12.12.84

TEST RUN NO.			1	2	3	4	5	6	7	8	9
BOILER LOAD		MW	17,9	18,2	10,9	10,6	17	16,8	17	10	16,3
GAS INLET HEATER		°C	381	389	322	335	375	365	-	-	383
GAS OUTLET HEATER		°C	249	259	190	200	246	239	-	-	253
O_2 (WET)		%	3,3	3,5	4,3	4,2	3,7	3,9	-	-	3,8
LIMESTONE FLOW		kg/h	0	648	0	372	0	336	0	0	600
Ca/S - RATIO		-	-	2,5	-	2,5	-	2,5	-	-	2,5
OIL FLOW	BR. 1	l/h	50	50	50	50	50	50	185	150	50
MILL TEMP.	"	°C	98	89	92	91	92	92	-	-	94
PRIM. AIR (n.p.t.)	"	M^3/h	1145	1300	1340	1380	1660	1655	-	-	1635
SEC. AIR (n.p.t.)	"	M^3/h	6850	6935	6625	6465	6800	6775	-	-	6840
TERT. AIR (n.p.t.)	"	M^3/h	1995	2425	1930	1755	1245	855	-	-	1095
n_p	"	-	1,02	1,00	0,93	0,93	1,14	1,20	-	-	1,16
OIL FLOW	BR. 2	l/h	50	50	0	0	50	50	185	0	50
MILL TEMP.	"	°C	108	88	-	-	91	90	-	-	94
PRIM. AIR (n.p.t.)	"	M^3/h	1170	1355	200	200	1620	1645	-	-	1655
SEC. AIR (n.p.t.)	"	M^3/h	7075	7165	1500	1500	6800	6775	-	-	6840
TERT. AIR (n.p.t.)	"	M^3/h	1945	2030	-	-	1625	805	-	-	995
n_p	"	-	1,03	1,04	-	-	1,09	1,21	-	-	1,17
SO_2		ppm	2430	1200	2587	1299	1108	610	2119	1823	1023
NO_x		ppm	278	262	253	198	253	242	673	442	242
CO		ppm	66	59	235	191	55	58	9	194	-
HC		ppm	0	0	0,4	0	0	0	1	14	0
O_2 (DRY)		%	4,8	5,5	6,3	5,4	5,5	5,5	5,3	9,3	5,6
SO_2		%	-	51	-	50	-	45	-	-	50
NO_x		%	59	61	62	71	62	64	-	-	64

9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

A NO_x REDUCTION OF ABOUT 60% WAS ATTAINED AND THE DESULPHURISATION EFFICIENCY WAS 51%. THE HALF-LOAD TESTS NO. 3 AND 4 WERE EACH CARRIED OUT WITH THE LOWER OF THE TWO BURNERS UNDER FULL LOAD. THE LEAKAGE AIR ENTERING THROUGH THE IDLE UPPER BURNER WAS CONSIDERED AS TERTIARY AIR AND USED IN THE CALCULATION OF THE PRIMARY AIR INDEX n_p = 0.93. THE DEGREE OF DESULPHURISATION WAS 50% AND THE NO_x REDUCTION 62 AND 71% RESPECTIVELY.

TESTS 5 AND 6 WERE DESIGNED TO PROVIDE INDICATIONS ON THE BEHAVIOUR OF THE PLANT WHEN FIRING THE COAL NORMALLY USED, WHICH HAS A LOWER SULPHUR CONTENT (S = 1.5%).

IT WAS ONLY POSSIBLE TO REACH A BOILER LOAD OF ABOUT 17 MW. FOR THE SAME CA/S RATIO, THE DEGREE OF DESULPHURISATION WAS AT 45% SOMEWHAT LOWER AND THE NO_x REDUCTION WAS APPROXIMATELY THE SAME.

TESTS 7 AND 8 WERE INTENDED TO SHOW THE OPERATING RESULTS OF BOILER NO. 1, WHERE LARGE QUANTITIES OF BACK-UP OIL HAD TO BE FIRED WITH THE OLD FIRING SYSTEM USING THE TEST COAL AT BOTH FULL LOAD AND HALF LOAD.

TEST NO. 9 IS A REPETITION OF TEST NO. 2, i.e. FULL LOAD FIRING THE TEST COAL WITH INJECTION OF LIMESTONE. THE ADJUSTMENT OF THE PARTIAL AIR FLOWS WAS SUCH THAT HIGHER PRIMARY AIR QUANTITIES AND LOWER TERTIARY AIR QUANTITIES WERE UTILISED WHEN COMPARED WITH TEST NO. 2.

9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

BEFORE LIME INJECTION WAS COMMENCED, A FIGURE OF 2060 ppm SO_2, REFERRED TO 3% O_2, WAS MEASURED. THE DEGREE OF DESULPHURISATION FOR A Ca/S RATIO = 2.5 WAS THEREFORE ALSO 50%. NO_x REDUCTION, REFERRED TO TEST NO. 7, WAS 64%.

AT THE END OF TEST NO. 6 THE QUANTITY OF LIME INJECTED WAS VARIED, i.e. IT WAS FIRST LOWERED TO A RATIO EQUIVALENT TO Ca/S = 1.5 AND THEN RAISED TO Ca/S = 3.5. THE ALTERATION IN SO_2 CAPTURE WHICH RESULTED IS SHOWN IN THE GRAPH ON THE NEXT PAGE.

9.2.5 GUARANTEES

THE OFFICIAL EVALUATION OF THE TESTS AND INVESTIGATION WHETHER THE GUARANTEE FIGURES ARE COMPLIED WITH WILL BE CARRIED OUT BY G.A. ROBB ASSOCIATED.

IT WAS OBSERVED THAT THE GUARANTEED REDUCTION OF SO_x AND NO_x by 50% WAS ACHIEVED.

IN NO CASE DID THE BOILER EXIT TEMPERATURE (ON EXIT FROM THE FURNACE) EXCEED 390°C. THE REQUIREMENTS IN RESPECT OF FLAME LENGTH AND REMOVAL OF DEPOSITS BY THE SOOTBLOWERS CAN ALSO BE CONSIDERED AS HAVING BEEN FUFILLED DURING THESE TESTS.

STEINMÜLLER

Proj./Auftr.-Nr.	Blatt
09.7139	5.7 B
Kennwort	Datum
CPB GAGETOWN	12. 12. 1984

SO_2 - Reduzierung durch Testgrau Nr. 2
(SO_2 Gem. in ppm SO_2)

9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

9.3 TEST SERIES 2

9.3.1 OBJECTIVE

FOLLOWING THE COMPLETION OF COMMISSIONING AND ACCEPTANCE TESTING IN NOVEMBER 1984, THE THROAT CONTOUR ON BOTH BURNERS, WHICH HAD NOT BEEN EXECUTED IN ACCORDANCE WITH THE DRAWINGS, WERE MODIFIED. A STABLE COAL FLAME COULD NOT BE MAINTAINED CONTINOUSLY. TEST AIMED AT OPTIMIZING THE FIRING SYSTEM WERE CONDUCTED FROM THE 22nd TO THE 28th OF MARCH 1985.

9.3.2 SUMMARY OF TEST RESULTS

ON MARCH 22nd, UNIT NO. 2 WAS OPERATED WITH THE SAME SWIRL SETTING AS THE NOVEMBER TESTS. IT WAS FOUND NECESSARY TO REDUCE THE SECONDARY AIR SWIRL IN ORDER TO AVOID PUFFING AND ESTABLISH A STABLE FLAME. THE BEST WAY WAS TO REDUCE THE SWIRLER BY 65 MM (MAX. 130 MM TRAVEL). THE AIR FLOWS COULD THEN BE ADJUSTED TO NEAR DESIGN VALUES. THIS IN GENERAL HAS TRANSLATED IN A MUCH

9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

IMPROVED OPERATION. WITH BOTH BURNERS IN OPERATION AND THE MAXIMUM LOAD ATTAINABLE ON MARCH 24th OF BETWEEN 15 AND 18 MW, IMPROVED FLAME STABILITY WAS NOTICEABLE. HOWEVER, A LOWER RATE OF TERTIARY AIR FLOW (STAGING AIR) HAD TO BE EMPLOYED BECAUSE OF OUTSIDE-AIR INGRESS VIA THE OTHER NON-FIRING BURNER AND EXISTING FURNACE OPENINGS.

THE COAL ANALYSIS, COMBUSTIBLE IN ASH, SALIENT PANEL READINGS AND CONTROL MEASUREMENTS AND THE COMBUSTION AIR DAMPER SETTINGS AS A FUNCTION OF PLANT OUTPUT ARE SHOWN IN THE FOLLOWING PAGES. THE LIMESTONE ANALYSIS ARE GIVEN IN SECTION 8.

COAL ANALYSIS

PROXIMATE ANALYSIS

	AS REC'D	DRY
MOISTURE	1.26	-
ASH	5.88	5.95
VOLATILE MATTER	32.89	33.31
FIXED CARBON	59.97	60.74

ULTIMATE ANALYSIS

CARBON	75.27
HYDROGEN	4.98
SULPHUR	1.49
NITROGEN	1.61
ASH	5.95
OXYGEN (BY DIFFERENCE)	10.70

COMBUSTIBLE IN FLY ASH

DATE 1985	LOAD MW	COMBUSTIBLE CONTENT, %
25-3	5	67.7
27-3	10-12	52.1
28-2	10	53.2

EVALUATION OF READINGS BOILER NO. 2
CFB GAGETOWN

DATE: 23.05.85 SHEET 1

READING NO.			1	2	3	4	5	6	7	8	9
BOILER LOAD		MW	10,3	11	16	17	10	4,8	5,2	7	11
GAS INLET HEATER		°C	230	250	308	272	203	170	170	180	190
GAS OUTLET HEATER		°C	358	390	+400	405	370	290	290	310	320
O_2 (WET)		%	6,5	6,5	5,5	5,8	5,9	9,5	7,8	6,5	5,6
OIL FLOW	BR. 1	l/h	50	50	50	50	50	50	50	50	50
MILL TEMP.	"	°C	92	90	102	102	99	108	109	103	100
PRIM. AIR (n.p.t.)	"	M^3/h	1654	1242	1356	1375	1201	631	631	1180	1479
SEC. AIR (n.p.t.)	"	M^3/h	1029	5705	6662	6662	6662	5958	5439	6436	8063
TERT. AIR (n.p.t.)	"	M^3/h	1029	497	2601	2439	2439	0	0	656	2395
OIL FLOW	BR. 2	l/h	0	50	50	50	0	0	0	0	0
MILL TEMP.	"	°C	-	86	100	103	-	-	-	-	-
PRIM. AIR (n.p.t.)	"	M^3/h	0	1242	135	1357	0	0	0	0	0
SEC. AIR (n.p.t.)	"	M^3/h	0	6436	6662	6662	0	0	0	0	0
TERT. AIR (n.p.t.)	"	M^3/h	0	603	2601	2439	0	0	0	0	0

EVALUATION OF READINGS BOILER NO. 2

CFB GAGETOWN

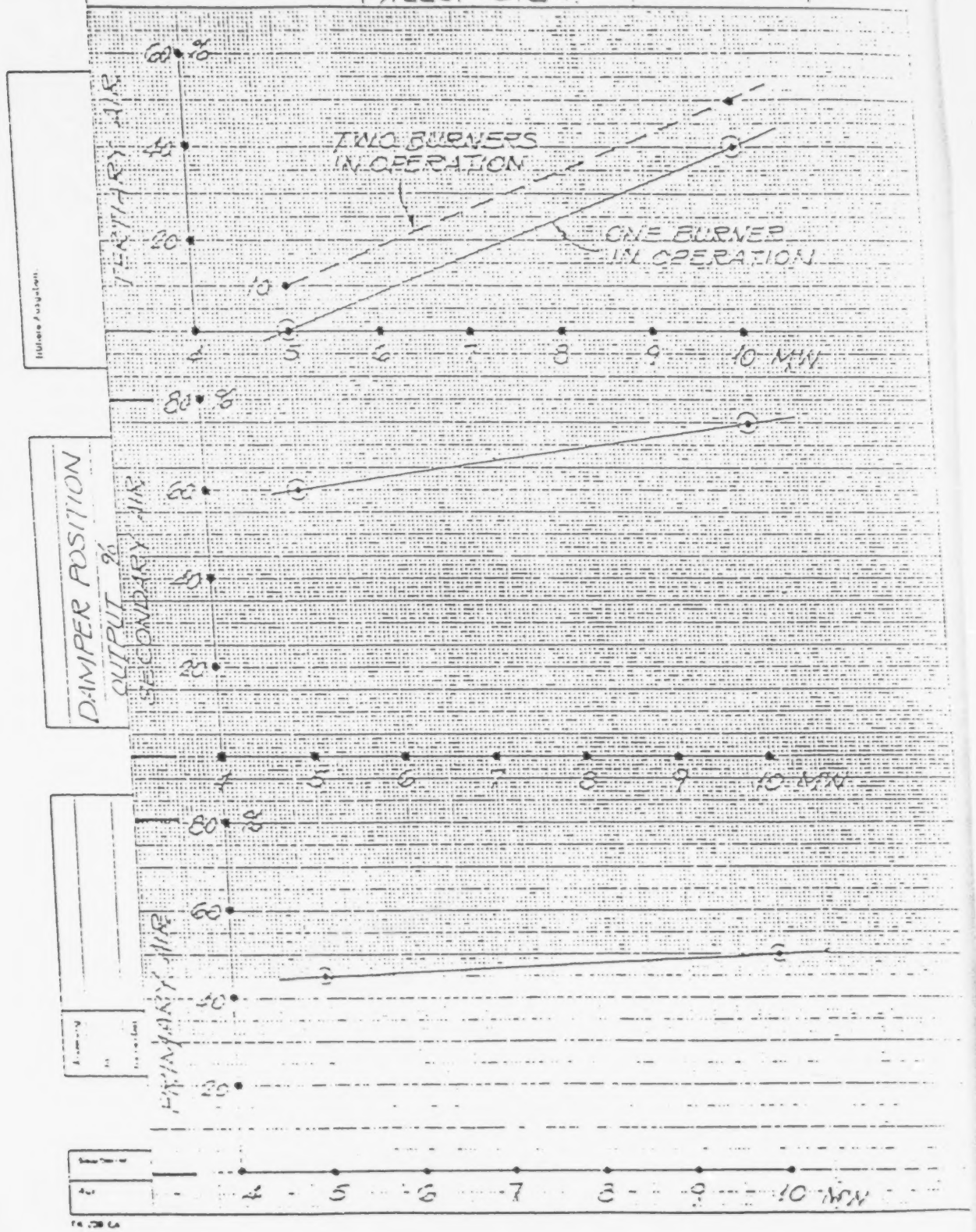
DATE: 23.05.85

SHEET 2

READING NO.			10	11	12
BOILER LOAD		MW	15	12,2	9,5
GAS INLET HEATER		°C	192	220	190
GAS OUTLET HEATER		°C	379	350	320
O_2 (WET)		%	5,5	6,5	7,5
OIL FLOW	BR. 1	l/h	50	50	0
MILL TEMP.	"	°C	102	102	92
PRIM. AIR (n.p.t.)	"	M^3/h	1428	1496	1608
SEC. AIR (n.p.t.)	"	M^3/h	6436	6436	8068
TERT. AIR (n.p.t.)	"	M^3/h	1632	6436	1962
OIL FLOW	BR. 2	l/h	50	50	0
MILL TEMP.	"	°C	106	100	-
PRIM. AIR (n.p.t.)	"	M^3/h	1319	1512	0
SEC. AIR (n.p.t.)	"	M^3/h	6436	6202	0
TERT. AIR (n.p.t.)	"	M^3/h	1991	6202	0

STEINMÜLLER

CFB GAGETOWN	C83150
YLEC / D.G.A.	DEC. 4-1985



9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

9.4 TEST SERIES 3

9.4.1 OBJECTIVE

FURTHER TO THE COMPLETION OF COMMISSIONING SOME BURNER MODIFICATIONS, OTHER CORRECTIVE MEASURES WHERE IMPLEMENTED IN ORDER TO REDUCE HIGH UNBURNED COMBUSTIBLES IN THE FLY ASH. DURING THE COMMISSIONING PERIOD (TEST SERIES 2) FROM 23-11-84 TO 28-11-84 ALL ASH ANALYSES HAVE INDICATED AN AVERAGE OF 42.8% CARBON CARRY OVER.

9.4.2 BURNER MODIFICATIONS

BASED ON THE RESULTS OF TEST (SERIES 1) AND SUBSEQUENT TEST (SERIES 2), A NUMBER OF BURNER DESIGN CHANGES WERE INTRODUCED:

A) A FIXED SWIRLER WAS INSERTED IN THE P.F. ANNULUS CLOSE TO THE BURNER DISCHARGE.

B) BURNER OUTLET QUARL WAS EXTENDED BY 75 MM WHILE MAINTAINING SAME DISCHARGE ANGLE.

9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

C) A COUPLE OF VANES WERE ADDED TO EACH STAGING AIR OUTLET IN ORDER TO DEFLECT SOME OF THE STAGING AIR INWARD, SO SAME WOULD MIX SOONER WITH THE MAIN FLAME.

D) P.F./PRIMARY AIR VELOCITY WAS REDUCED BY MODIFYING THE INNER CORE AIR DUCT.

E) AMONG ABOVE CHANGES, IT HAD BECOME NECESSARY TO CONSIDER OTHER MEANS OF CONTROLLING MILL OUTLET TEMPERATURE WHICH WAS ACCOMPLISHED WITH THE USE OF FURNACE HOT GASES, EXTRACTED FROM THE FURNACE UPPER SECTION OF ASH HOPPER. THEREFORE SMALL NO. 2 OIL BURNERS WERE INSTALLED IN THE P.A. CONNECTING DUCT TO SERVE EACH PULVERIZER.

THE FLUE GAS VALVES AND BALANCED TEMPERING DAMPERS WERE THEN CONSIDERED REDUNDANT. THIS FEATURE FOR THAT SITE HAS TRANSLATED IN A VERY GOOD CONTROL OF MILL TEMPERATURE AND DETERMINATION OF P.F. VELOCITY IN THE BURNERS WITH HIGH PRECISION. THE OVERALL EFFICIENCY REMAINED THE SAME.

9.0 COMMISSIONING AND ACCEPTANCE TESTS (CONT'D)

9.4.3 SUMMARY OF TEST RESULTS

THE COAL ANALYSIS, COAL FINENESS, SALIENT MEASUREMENTS AND PANEL READINGS AND COMBUSTIBLE IN ASH ARE SHOWN ON THE FOLLOWING PAGES.

COAL ANALYSIS

PROXIMATE ANALYSIS	AS REC'D	DRY
MOISTURE	2.76	
ASH	9.59	9.86
VOLATILE	34.58	35.56
FIXED CARBON (BY DIFFERENCE)	53.07	54.58
ULTIMATE ANALYSIS		
CARBON	72.34	74.39
HYDROGEN	4.70	4.83
SULPHUR	2.37	2.44
NITROGEN	1.45	1.49
ASH	9.59	9.86
OXYGEN (BY DIFFERENCE)	6.79	6.99
HEAT VALUE		
CAL/GM	7083	7284
KCAL/KG	7083	7284
MJ/KG	29.66	30.50
BTU/LB	12749	13111

ASH FUSIBILITY	OXIDING °F (°C)	REDUCING °F (°C)
INITIAL DEFORMATION	2570 (1410)	1990 (1088)
SOFTENING-SPHERICAL	2590 (1421)	2095 (1146)
SOFTENING-HEMISPHERICAL	2595 (1424)	2205 (1207)
FLUID	2610 (1432)	2425 (1329)

COAL ASH ANALYSIS

COMPONENT	%
SIO2	41.19
AL203	22.04
FE203	27.66
T102	1.17
P205	0.05
CAO	0.92
MGO	0.56
SO3	1.40
NA20	0.39
K20	2.03
BAO	0.22
SRO	0.01
MN304	-
LOF	0.42

COAL FINENESS

SCREEN SIZE	WT %
+200	10.96
-200 +325	21.21
-325 +0	67.83
TOTAL	100

Gagetown December 1995 Tests
RESULT SUMMARY TABLE
(metric units)

DATE Dec	TIME	LOAD (MW)	FEEDRATE Lime-stone (kg/hr)	FEEDRATE O:1 L/hr	FEEDRATE Coal (kg/hr)	Ca/S Mole Ratio	SO2 Reduction	Efficiency	* % C IN FLY ASH	Unburnt Carbon Loss %
2	1130-1230	10.5	0	100.0	1567.5	0.00	0.00%	81.32%	38.54%	3.88%
2	1400-1545	10.0	139.7	100.0	1517.7	1.23	42.07%	79.98%	38.54%	3.87%
2	1615-1800	10.4	312.1	100.0	1583.1	2.61	58.74%	80.05%	38.54%	3.90%
3	1400-1500	15.75	0	100.0	2380.0	0.00	0.00%	80.34%	48.31%	5.00%
3	1630-1830	15.4	258.3	100.0	2341.9	1.44	24.50%	79.95%	42.10%	4.36%
3	1845-2030	15.1	361.2	100.0	2312.9	2.03	39.02%	79.72%	42.10%	4.36%

Gagetown December 1995 Tests
RESULT SUMMARY TABLE
(British units)

DATE Dec	TIME	LOAD MBTU per hr	FEEDRATE Lime-stone lb/hr	FEEDRATE O:1 lb/hr	FEEDRATE Coal lb/hr	Ca/S Mole Ratio	SO2 Reduction	Efficiency	* % C IN FLY ASH	Unburnt Carbon Loss %
2	1130-1230	35.8	0	186.9	3456	0.00	0.00%	81.31%	38.54%	3.88%
2	1400-1545	34.1	308.0	186.9	3346	1.13	42.07%	79.98%	38.54%	3.87%
2	1615-1800	35.5	688.0	186.9	3490	2.40	58.74%	80.05%	38.54%	3.90%
3	1400-1500	53.8	0	186.9	5247	0.00	0.00%	80.34%	48.31%	5.00%
3	1630-1830	52.5	569.4	186.9	5163	1.36	24.50%	79.95%	42.10%	4.36%
3	1845-2030	51.6	796.3	186.9	5099	1.92	39.02%	79.71%	42.10%	4.36%

* As a percentage of the ash from the coal only (not limestone)

Gaqetown December 1985 Tests
INPUT SUMMARY TABLE
(metric units)

DATE Dec	TIME	LOAD (MW)	LIME-STONE FEED RATE kg/hr	TEMPERATURE Air Heater AIR IN (C)	TEMPERATURE Air Heater GAS OUT (C)	* % C IN ASH	% O2 (wet)	OIL FLOW (L/hr)	POLLUTION REDUCTION % SO2	POLLUTION REDUCTION % NOx
2	1130-1230	10.5	0	30.3	207.0	38.54%	6.9	100.0	0.00%	4.92%
2	1400-1545	10.0	139.7	30.3	221.3	38.54%	7.8	100.0	42.07%	5.64%
2	1615-1800	10.4	312.1	32.7	229.0	38.54%	7.5	100.0	58.74%	5.93%
3	1400-1500	15.75	0	21.5	244.5	48.31%	3.0	100.0	0.00%	23.20%
3	1630-1830	15.4	258.3	19.0	254.0	42.10%	4.3	100.0	24.50%	32.29%
3	1845-2030	15.1	361.2	20.0	263.0	42.10%	4.1	100.0	39.02%	38.16%

Gaqetown December 1985 Tests
INPUT SUMMARY TABLE
(British units)

DATE Dec	TIME	LOAD MBTU per hr	LIME-STONE FEED RATE lb/hr	TEMPERATURE Air Heater AIR IN (F)	TEMPERATURE Air Heater GAS OUT (F)	* % C IN FLY ASH	% O2 (wet)	OIL FLOW lb/hr	POLLUTION REDUCTION % SO2	POLLUTION REDUCTION % NOx
2	1130-1230	35.8	0	86.5	404.5	38.54%	6.9	186.9	0.00%	4.92%
2	1400-1545	34.1	308.0	86.5	430.4	38.54%	7.8	186.9	42.07%	5.64%
2	1615-1800	35.5	688.0	90.8	444.2	38.54%	7.5	186.9	58.74%	5.93%
3	1400-1500	53.8	0	70.7	472.1	48.31%	3.0	186.9	0.00%	23.20%
3	1630-1830	52.5	569.4	66.2	489.2	42.10%	4.3	186.9	24.50%	32.29%
3	1845-2030	51.6	796.3	68.0	505.4	42.10%	4.1	186.9	39.02%	38.16%

* As a percentage of the ash from the coal only (not limestone)

Dec. 2. 1985

TIME	LIMESTONE FEEDRATE (kg/hr)	SO2 (PPM)	** Reduction %	NOx (PPM)	* Reduction %	CO	O2 % by vol.
11:30 to 11:45	0	1036.		477.5	4.49%	123.4	8.32
11:45 to 12:00	0	1064.		475.1	4.98%	99.2	7.67
12:00 to 12:15	0	1086.		473.5	5.29%	96.5	7.66
12:15 to 12:30	0	1113.		475.1	4.96%	97.9	7.67
11:30 To 12:30	0	1088.		475.3	4.92%	104.2	7.83
14:00 to 14:15		662.0	39.17%	460.0	7.99%	137.9	8.59
14:15 to 14:30		633.0	41.38%	467.2	6.54%	95.0	7.62
14:30 to 14:45	139.80	659.5	39.40%	483.1	3.37%	103.9	8.5
14:45 to 15:00	139.80	613.1	43.67%	472.7	5.45%	110.4	8.56
15:00 to 15:15	139.80	608.6	44.08%	473.2	5.35%	108.6	9.31
15:15 to 15:30	139.86	601.3	44.75%	474.3	5.12%	109.2	9.25
14:00 To 15:30	139.75	630.4	42.07%	471.8	5.64%	111.7	8.31
15:30 to 15:45		411.6	62.18%	466.2	6.74%	91.5	7.45
15:45 to 17:00		464.4	57.33%	471.0	5.80%	101.0	7.97
17:00 to 17:15		457.1	57.99%	473.5	5.30%	118.4	8.54
17:15 to 17:30	312.15	457.7	57.94%	471.4	5.72%	122.6	8.56
17:30 to 17:45	312.15	443.3	58.80%	470.4	5.82%	133.6	8.75
17:45 to 18:00	312.00	454.9	58.18%	469.6	6.09%	115.7	8.19
15:30 To 18:00	312.10	449.0	58.74%	470.3	5.83%	113.8	8.24

* Based on NOx emmisions of 500 PPM without the low NOx SOx burner determined during the 1982 tests and written into the contract.

** Based on typical SOx emissions without limestone taken just before limestone was added.

Note The PPM have been adjusted to 3% oxygen in the flue gas.

Dec. 3, 1985

TIME	LIMESTONE FEEDRATE (kg/hr)	SO2 (PPM)	SO2 Reduction %	NOx (PPM)	NOx Reduction %	CO (PPM)	O2 % by vol.
14:00 to 14:15	0.00	1165.		379.4	24.12%	57.5	4.62
14:15 to 14:30	0.00	1162.		380	24.00%	61.1	4.76
14:30 to 14:45	0.00	1164.		397.8	20.42%	56.8	4.78
14:45 to 15:00	0.00	1176.		378.6	24.27%	49.2	3.92
14:00 To 15:00	0.00	1167.		383.9	23.20%	56.2	4.52
15:30 to 15:45		913.6	21.73%	350.2	29.96%	57.2	5.28
15:45 to 17:00		948.2	18.77%	345.5	30.88%	32.8	4.79
17:00 to 17:15		859.6	26.36%	352.3	29.53%	45.9	5.69
17:15 to 17:30	252.86	860.5	26.28%	324.6	35.06%	56.8	5.49
17:30 to 17:45	252.86	838.1	28.20%	317.7	36.46%	111.4	6.27
17:45 to 18:00	251.00	867.4	25.68%	340.8	31.84%	47.3	4.89
16:30 To 18:00	258.29	881.2	24.50%	338.5	32.29%	58.6	5.40
19:00 to 19:15	365.76	816.3	21.49%	283.0	43.39%	50.4	7.73
19:15 to 19:30	365.76	734.5	37.07%	299.5	40.06%	62.0	5.35
19:30 to 19:45	365.76	682.4	41.54%	296.1	40.77%	57.4	5.34
19:45 to 20:00	360.00	598.8	48.69%	318.8	36.21%	40.1	5.16
20:00 to 20:15	355.09	675.5	42.12%	336.1	32.77%	41.5	5.31
20:15 to 20:30	355.09	662.8	43.22%	321.2	35.75%	43.0	6.4
19:30 To 20:30	361.24	711.8	39.02%	308.2	39.16%	49.1	5.98

* Based on NOx emmisions of 500 PPM without the low NOx/SOx burner determined during the 1982 tests and written into the contract.

** Based on typical SOx emissions without limestone taken just before limestone was added.

Note: The PPM have been adjusted to 3% oxygen in the flue gas.

REPORT NUMBER: AS/85/107 DATE: November 28, 1985
JOB NUMBER: 082000/031A
SUBMITTED BY: Mr. Yves Lecompte
Volcano Ltd.
4300 Beaudry
St. Hyacinthe, Quebec

Combustibles in Ash (at 750°C)

Sample	% Combustible
Ash #1: 26 Nov. 9 a.m.	76.8
Ash #2: 25 Nov. 8 p.m.	81.2
Ash #1: 25 Nov. 5 p.m.	79.4
Ash #1: 24 Nov. 3 p.m.	71.3
Ash #2: 23 Nov.	76.7
Ash #3: 23 Nov. 1:45	74.2
Unit #1: 26 Nov. 2 p.m.	44.3
Ash: 26 Nov. 5 p.m.	74.2
Ash: Unit 2: 27 Nov. 9:10 a.m.	70.3
Ash #2: 26 Nov. 2 p.m.	76.8
Ash: 27 Nov. 1:30 p.m.	65.7
Ash: Unit #2: 29 Nov. 2 p.m.	47.3
Ash: Unit #2: 28 Nov. 8:15 p.m.	51.1
Ash: Unit #2: 28 Nov. 3 p.m.	36.6
Ash: Unit #2: 29 Nov. 5 p.m.	51.2
Ash: Unit #2: 30 Nov. 11 a.m.	37.1
Ash: Unit #2: 1 Dec. 9 a.m.	41.3
Ash: Unit #2: 1 Dec. 3:45	24.5
Ash: Unit #2: 2 Dec. 1:15	39.5
Ash: Unit #2: 3 Dec. 3:30 p.m.	50.4
Ash: Unit #2: 3 Dec. 6:30 p.m.	33.1
Ash: Unit #2: 3 Dec. 8:30 p.m.	21.0

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10.0 CONCLUSIONS ON INSTALLED SM-BURNER PROJECT

THE DEVELOPMENT PROGRAM OF THE STAGED MIXING BURNER CONCEPT AT CFB GAGETOWN YIELDED THE FOLLOWING RESULTS:

- THE STAGED MIXING CONCEPT PRODUCED SIGNIFICANT REDUCTIONS IN NO_x FORMATION WITH EFFECTIVE IN-FLAME DESULPHURIZATION VIA A CIRCUMFERENTIAL SORBENT ADDITION TECHNIQUE.

- THE NO_x-FORMATION REDUCTION ACHIEVED WAS 60% IN COMPARISON TO CONVENTIONAL COMBUSTION WHEREAS THE IN-FLAME DE SO_x-PROCESS RESULTED IN A 51% DESO_x EFFICIENCY WITH A SORBENT ADDITION CORRESPONDING TO A RATIO OF Ca/S = 2.5

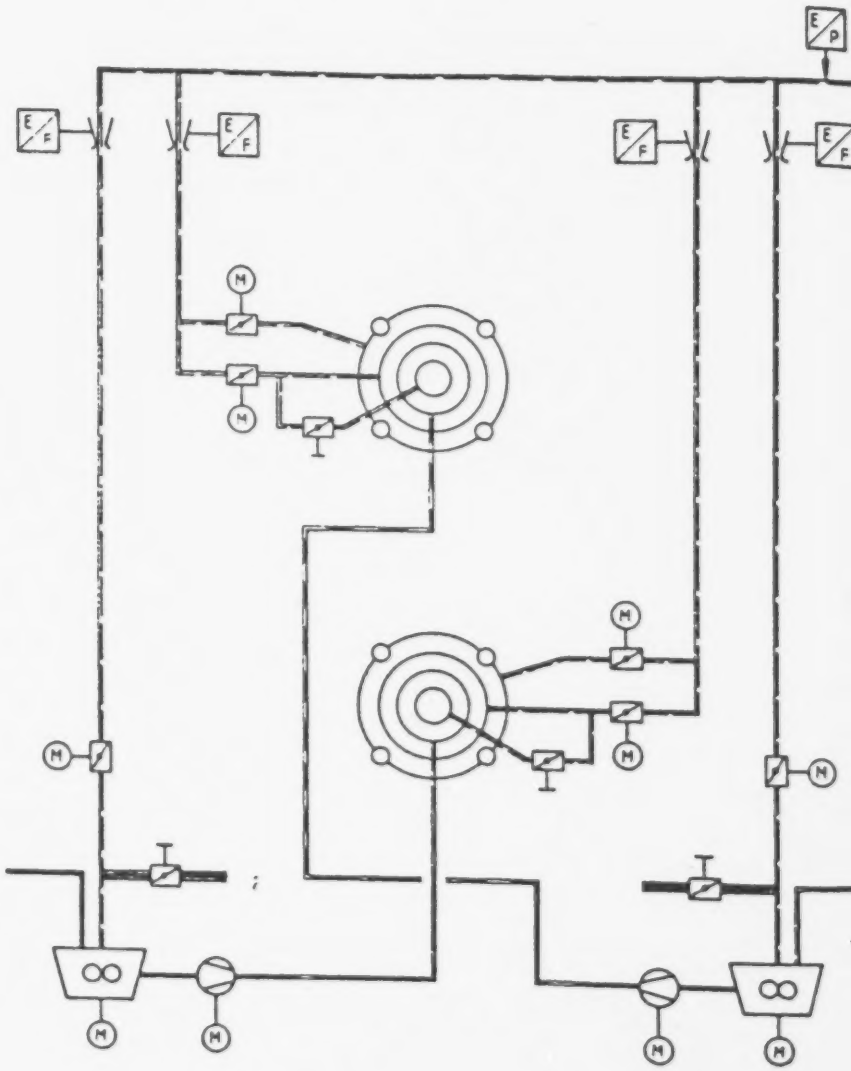
THE SM-BURNER PERFORMED IN A SAFE AND STABLE MANNER OVER A WIDE OPERATING RANGE AND WITHOUT SUPPORTING FUEL. PULSATION-FREE OPERATION WAS OBTAINED.

ALTHOUGH THE INITIAL TESTS SHOWED SATISFACTORY PERFORMANCE FOR NO_x AND SO_x SOME CONCERN WAS CAUSED BY EXCESSIVE CARBONACEOUS MATTER IN THE FLY ASH.

A CROSSCHECK WITH FLY ASH OBTAINED FROM UNMODIFIED BOILER NO. 1, INDICATED A CHANGE IN FLY ASH COMPOSITION, THAT COULD HAVE BEEN CAUSED BY THE BURNER QUARL NOT BEING INSTALLED AS PER DESIGN CONCEPT.

10.0 CONCLUSIONS ON INSTALLED SM-BURNER PROJECT (CONT'D)

AFTER CHANGING THE BURNER QUARLS AND AN APPROPRIATE ADJUSTMENT OF THE CLASSIFIERS, FURTHER TESTS SHOWED THAT THE UNBURNT COMBUSTIBLE IN THE FLY ASH, HAD NOT BEEN REDUCED TO AN ACCEPTABLE LEVEL AND THAT FLAME PULSATIONS WERE FREQUENT.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83150-A1

Project: CFB Gagetown

STEINMÜLLER
GUMMERSBACH

R & I DIAGRAMME
CHARBON - AIR
P & I DIAGRAM
COAL - AIR

1983	On	By	Ext.
Drn.	22 09	Stiebe	2902
Chk'd			
Code space through space			
Scale ——			

General tolerances see SN 1 Sh. 10

09.7139 S02 001

Based on:

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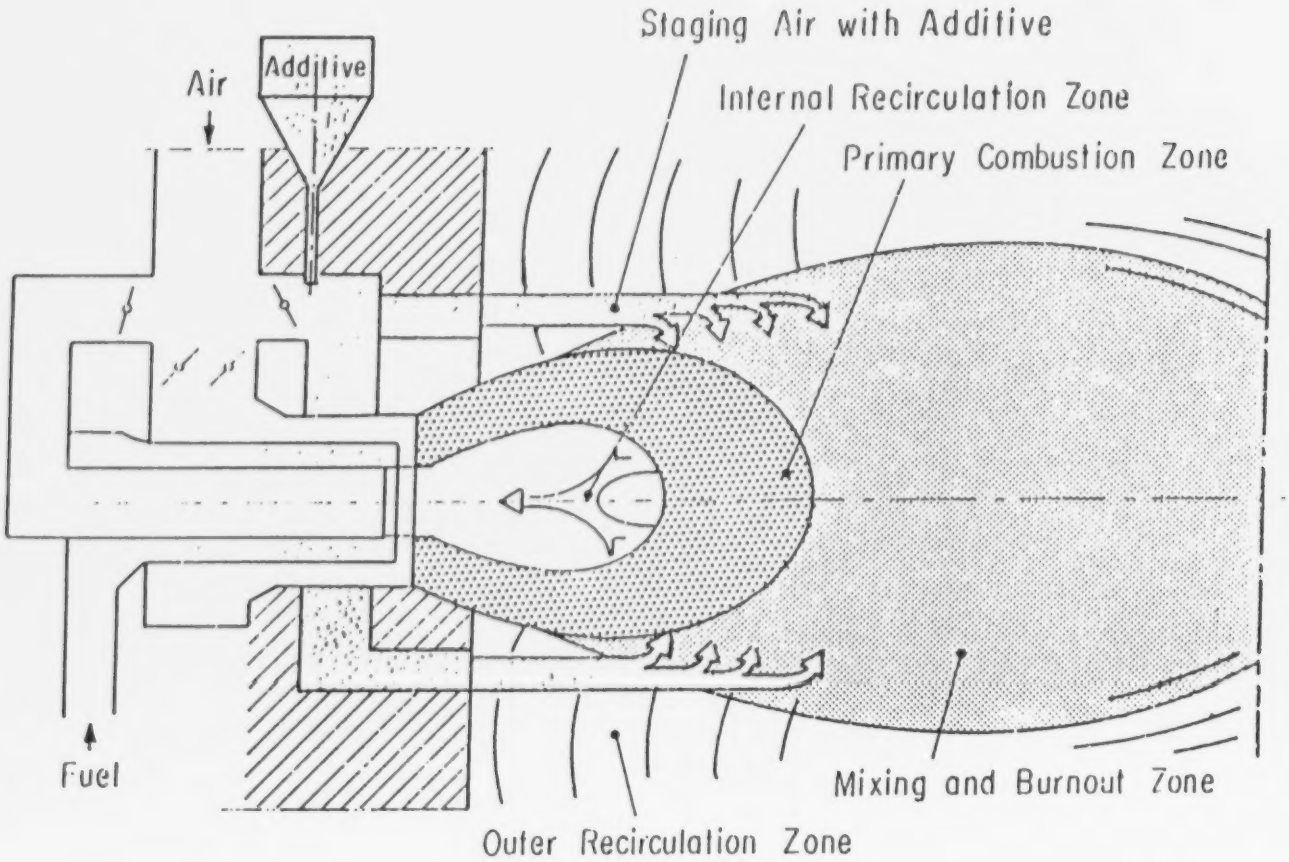

Direct Desulfurization through Additive Injection around the SM Burner

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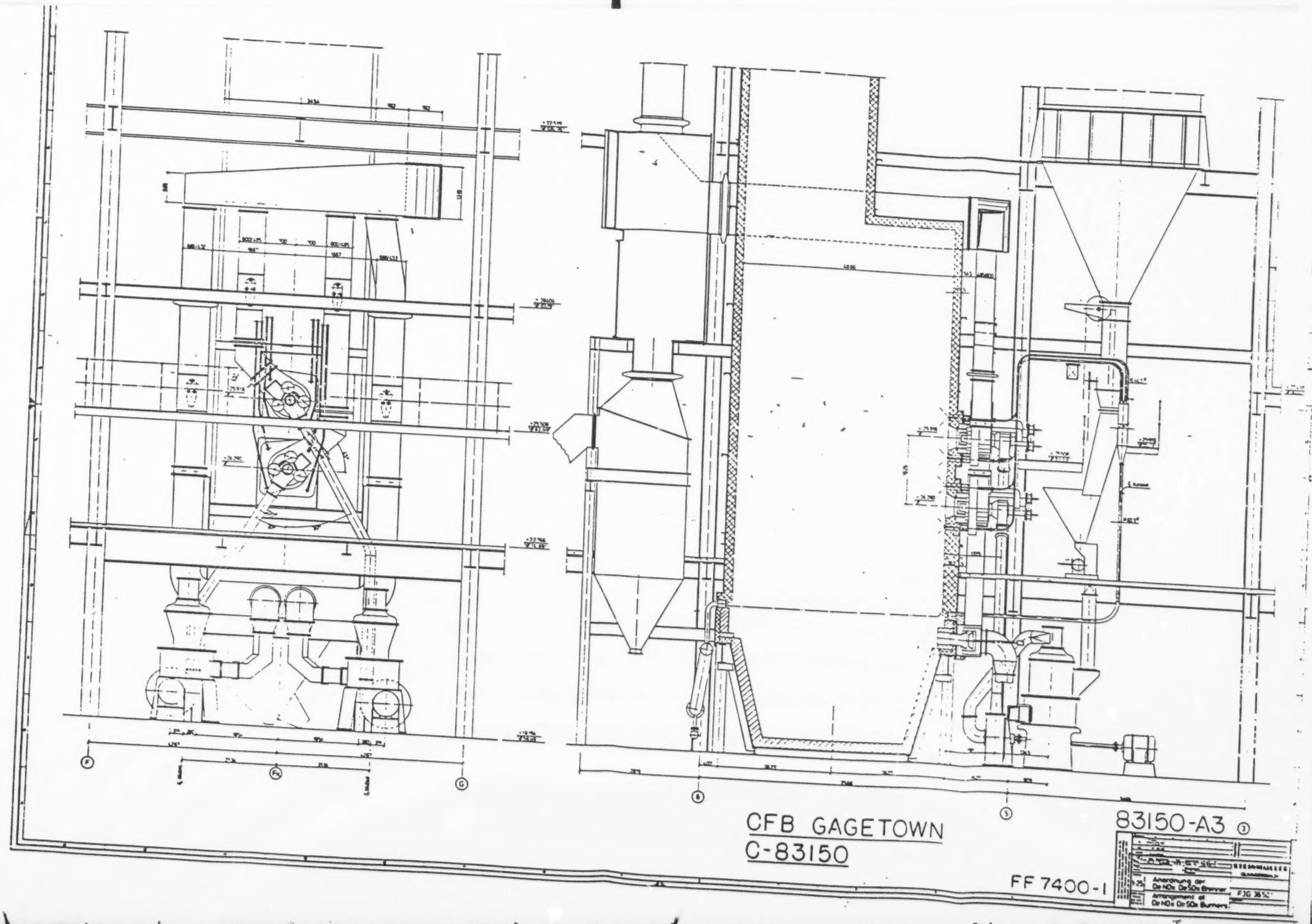
VOLCANO



CFB GAGETOWN
C-83150

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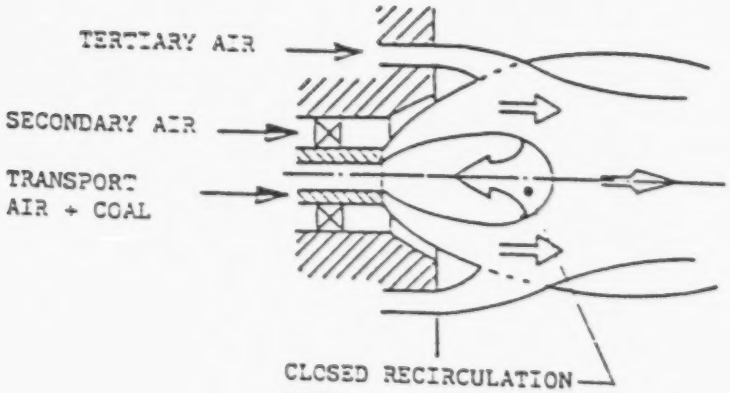
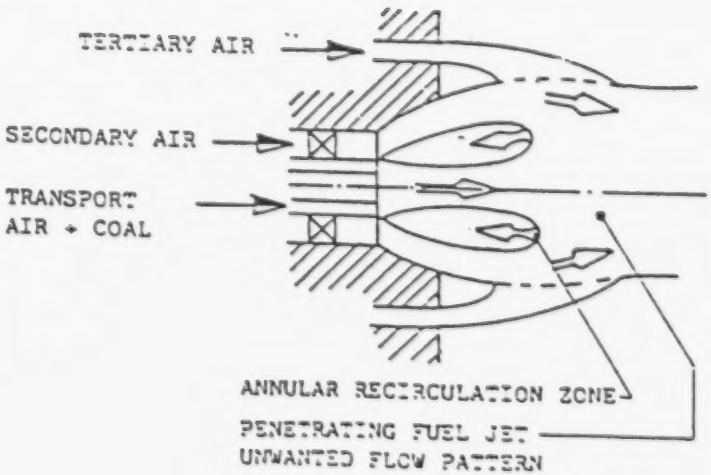
$\frac{S}{d}$ HIGH



FLOW PATTERN

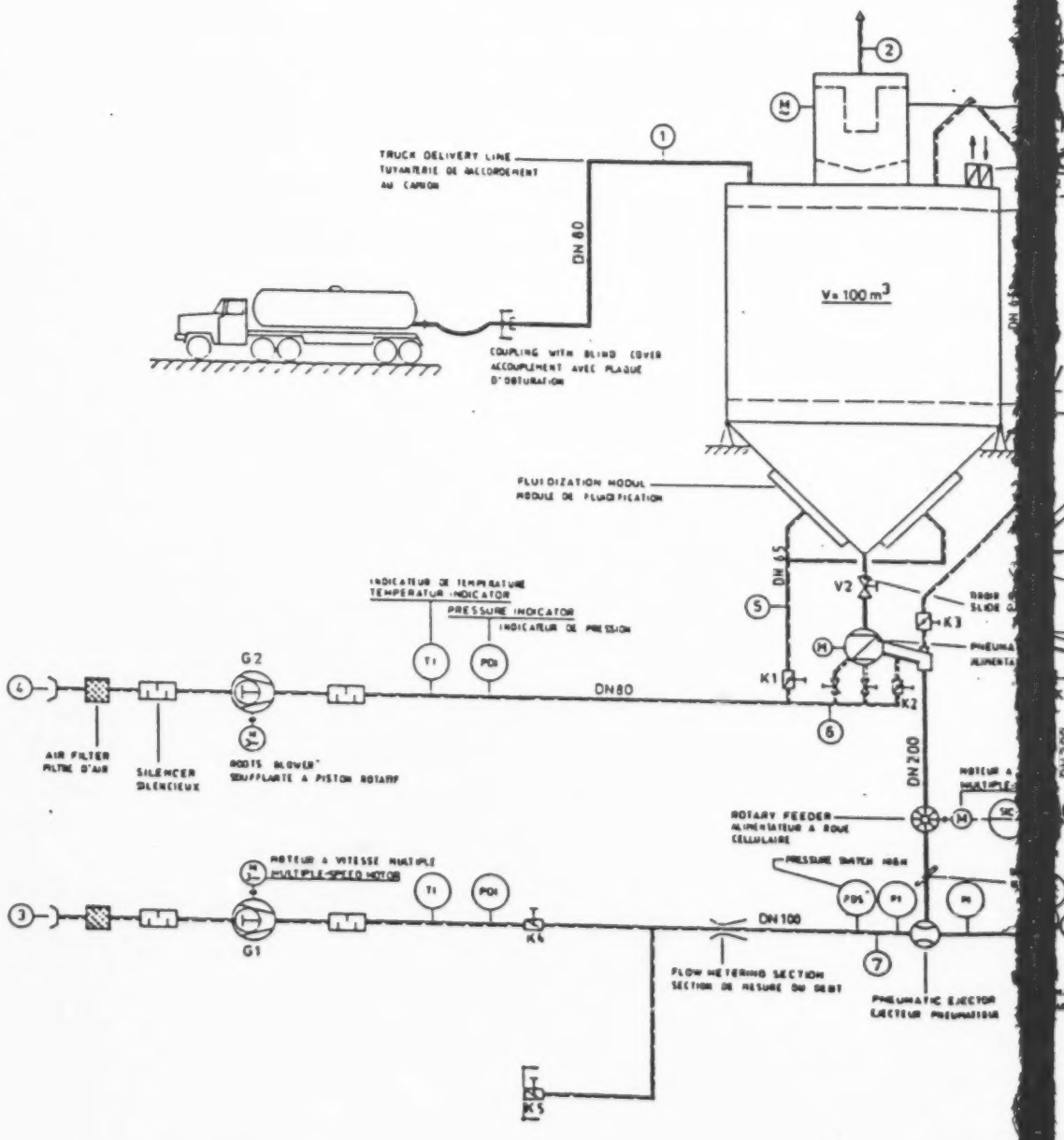
$\frac{S}{d}$ LOW



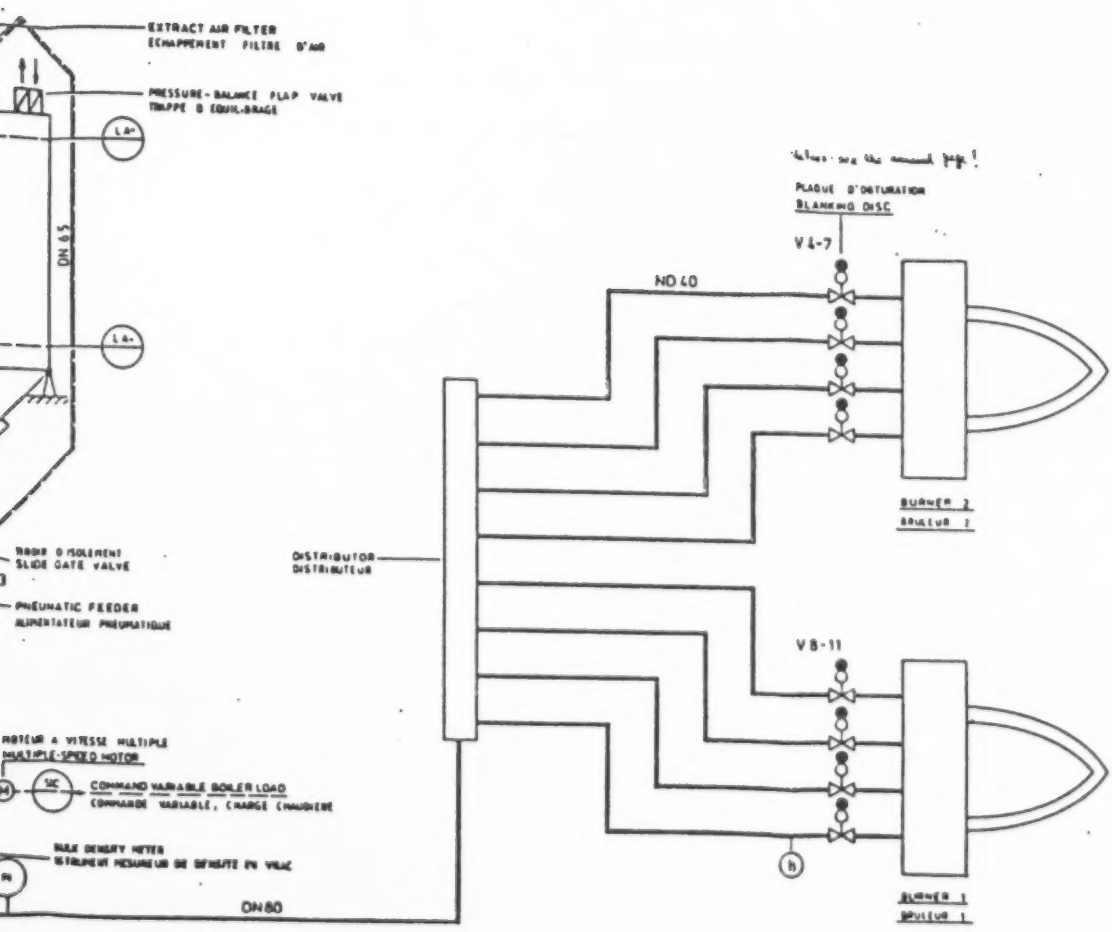
UNWANTED FLOW PATTERN

SM-BURNER. FLOWPATTERN DEPENDING ON PREVAILING BURNER AERODYNAMICS.

VOLCANO



POINT / MEDIUM	①	②	③	④	⑤	⑥	⑦	⑧
$\dot{m}_{air}$ kg/s	0.139	0.2304	0116	0.0914	0.0637	0.0277	0.116	0.0145
t_{air} °C	50	50	25	25	60	60	130	130
p_{air} mbar	1000	1000	1000	1000	1400	1400	2000	1000
$\dot{m}_{CaCO_3}$ kg/s	—	—	—	—	—	—	0.333	0.0416
$\dot{m}_{Cement}$ kg/s	—	—	—	—	—	—	0.25	0.0313



CFB GAGETOWN
C-83150

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STEINMULLER
GUMMERSBACH

FLOW DIAGRAM ADDITIVE INJECTION SYSTEM
SCHEMA DE PROCEDES SYSTEME D'INJECTION D'ADDITIF

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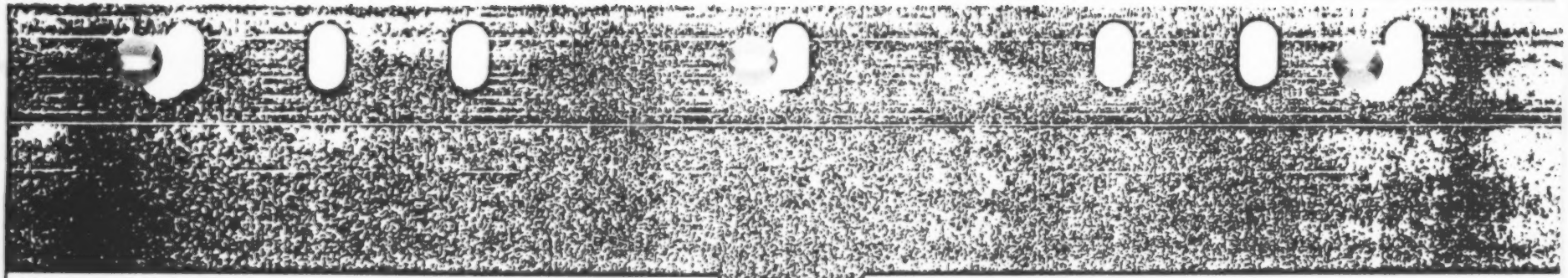

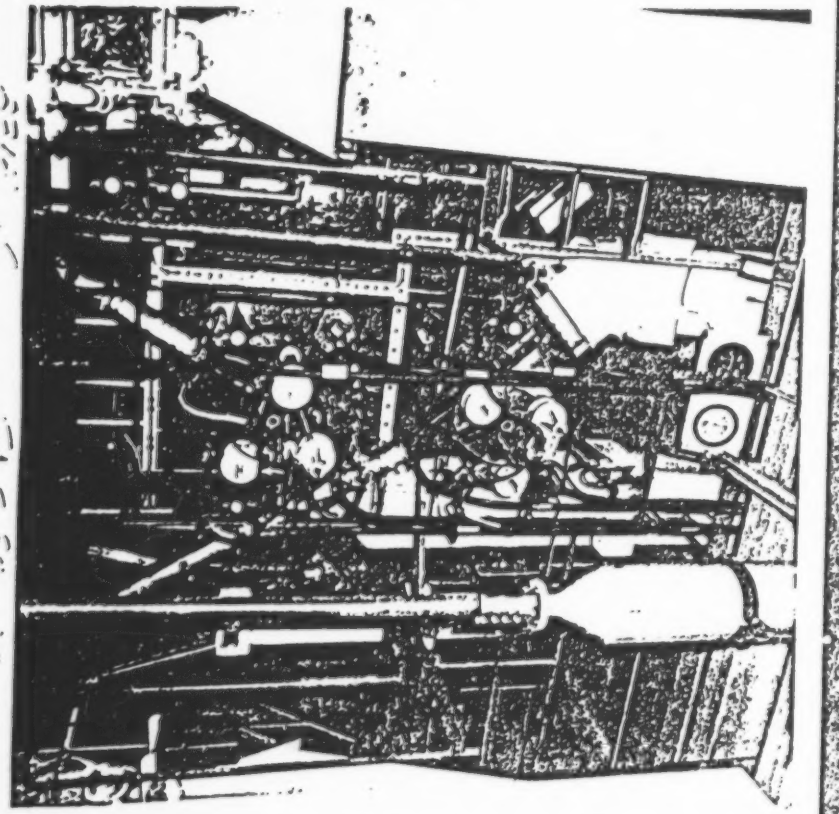

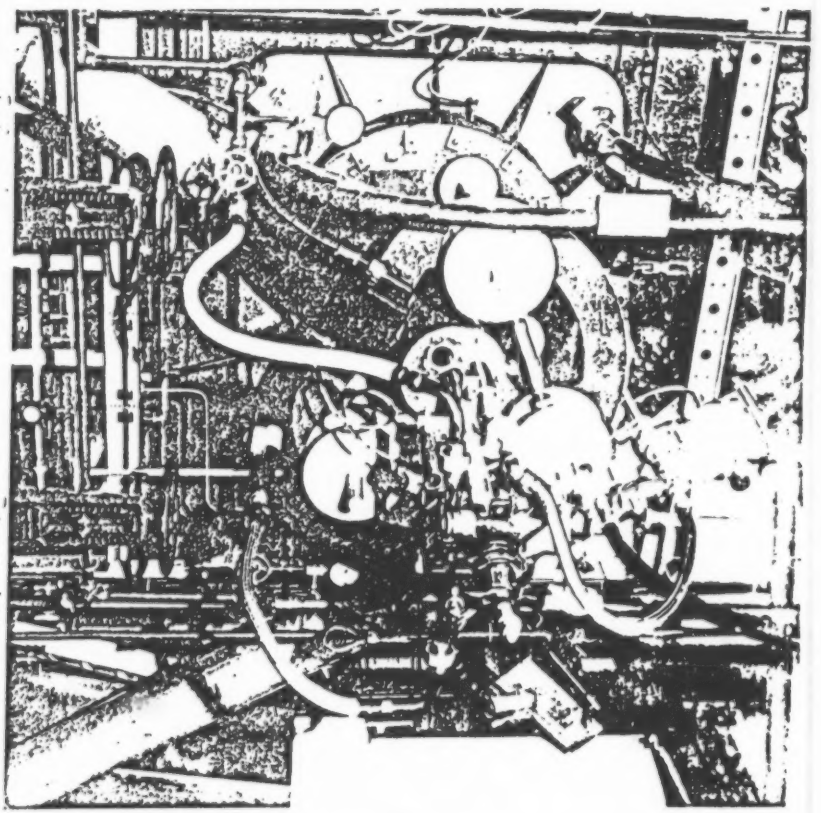

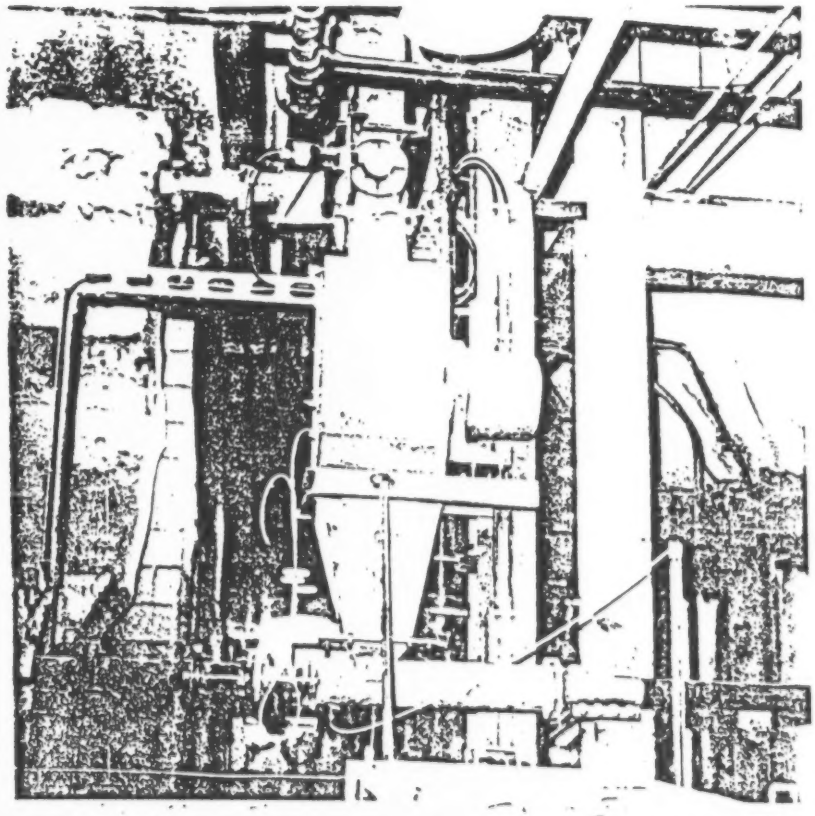

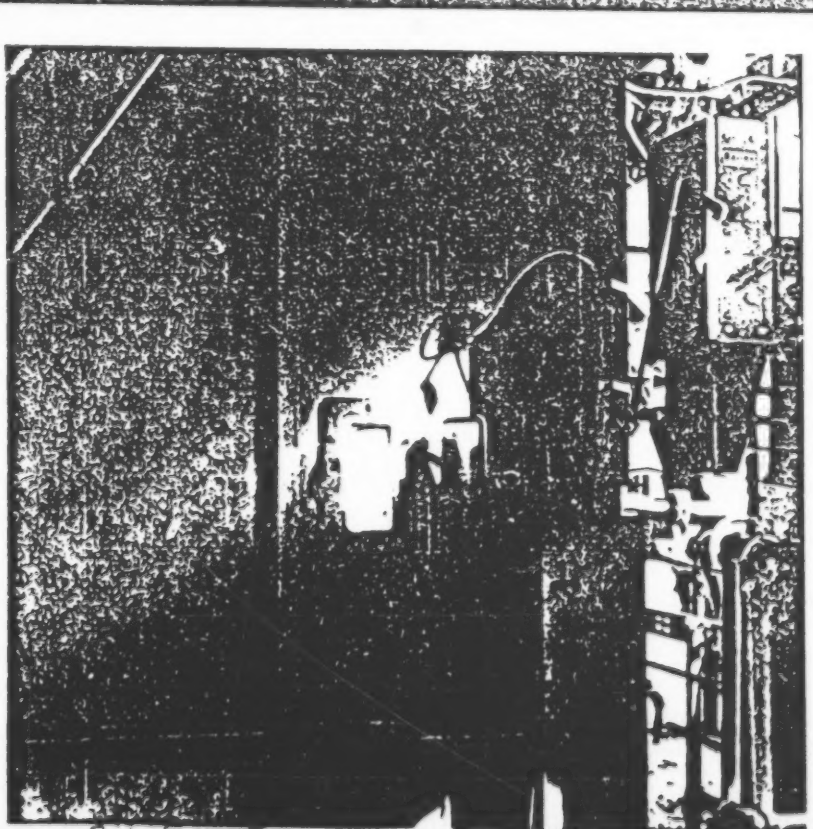

12.0 BASELINE TEST RESULTS

The following table summarizes the baseline test results including boiler efficiency and mole ratio calculations for full load tests.

TEST RESULTS

DAY	HOUR	UNIT	LOAD MW	% O2 <***> (+++)	NOx <mg/MJ> (ppm)	SO2 <mg/MJ> (ppm)	CO ppm	BLR EFF% *	GAS TEMP ***	Ca/S MOLE
26	845-1145	2	20	<3.6> (3.6)	<296> (480)	<1665> (1920)	18	85.6	211 C	0
26	1442 — 1628	2	10	<3.8> (3.8)	(300)	(2100)	**			0
27	930-1230	2	9	<4.0> (4.0)	(370)	(1930)	**			0
28	845-1145	3	20.6	<4.3> (6.0)	<360> (590)	<1620> (1970)	16	84.06	240 C	0
28	1545— 1600	3	10.5	(6.2)	(420)	(1990)	26			0
29	800-1100	3	18.58	<4.74> (6.5)	<469> (720)	<1158> (1280)	1.5	82.47	260 C	3.25
29	1315— 1615	3	8.5	(7.2)	(420)	(1200)	18			N.A.
30	900-1100	3	19.68	<4.51> (6.1)	<429> (660)	<1129> (1250)	1.7	82.77	256 C	3.13
30	1405— 1550	3	19.96	<4.54> (6.3)	<459> (750)	<1131> (1330)	1.1	82.19	269 C	2.72

* Boiler efficiencies were calculated using the asme heat loses method.

** CO fluctuated too much to take proper average reading.

*** Sampling point: Were the flue gas exits the air heater. NO_x, SO2 AND CO readings are corrected to 3% oxygen.

+++ Sampling points: Duct from the test boiler, just before the settling chamber.

NOTE: From March 26 to 27, the tests were done on Unit 2.
After and including the 28th, Unit 3 was used.
Test from the 29th through the 30th, involved limestone.

12.0 BASELINE TEST RESULTS (CONT'D)

MARCH 30/82, FULL LOAD, WITH LIMESTONE (AFTERNOON)

THE FOLLOWING IS A RESUME OF THE LIMESTONE FEEDRATES FOR THE TWO MARCH 30TH TEST IN LB/HR:

LIMESTONE FEEDRATES (LB/HR) (MARCH 30, 1982, AM)

MILL	TIME (hour)		FEED RATE
	START	STOP	LB/HR
LOWER	9:00	16:00	752
UPPER	9:00	10:00	881 *
	10:00	16:00	559
TOTAL	9:00	10:00	1633
	10:00	16:00	1311

NOTE: FOR ALL THE LIMESTONE TESTS, THE SMOKE LEAVING THE STACK WAS WHITE.

* THE UPPER MILL TRIPPED AT 12:46, PROBABLY BECAUSE OF THE INCREASED VOLUME IT HAD TO HANDLE (SEE 5.0 RESULTS, ITEM 3). OTHER THAN THIS TEMPORARY INTERRUPTION, THE UPPER MILL LIMESTONE FEEDRATE REMAINED FAIRLY CONSTANT.

12.0 BASELINE TEST RESULTS (CONT'D)

PULVERIZED MATERIAL PARTICLE SIZE

(PERCENTAGE OF PARTICULES GREATER THAN 250, 150 & 106 u IN DIAMETER.)

	% OVERSIZED		
	250 u	150 u	106 u
PULVERIZED COAL MARCH 28	0.2	0.7	2.6
PULVERIZED COAL AND LIMESTONE MARCH 30, AM	97.5	98.7	99.3

OIL FLOW FOR FLAME STABILIZATION

TEST CONDITIONS	DAY	Oil Flow		BTU Oil	lb Oil
		L/hr	lb/hr	BTU (Coal + Oil)	lb (Coal + Oil)
Unit 2	26 AM	109	204.1	0.050	0.037
UNIT 3	28 AM	143	267.6	0.063	0.047
" " with	29 AM	141	263.8	0.067	0.050
" " lime-	30 AM	182	340.5	0.082	0.061
" " stone	30 PM	177	331.4	0.078	0.058

INDIRECT BOILER EFFICIENCY ANALYSIS

****

DESCRIPTION:GAGETOWN TEST: MAR 28, AM; FL; NO LIMESTONE; OIL ONLY
BOILER DESCRIPTION:UNIT 3
MAXIMUM RATING OF UNIT: 70000 LBS. OF STEAM/HOUR
: 67.9216 MBTU/HR
NUMBER OF WATER WALLS: 4
FUEL FIRED DURING TEST: 8507
ENTHALPY RISE THRU BLR.: 7.03E+07 BTU/LB
FUEL CONSTITUENTS
****

%'S BY WEIGHT

TEST	CARBON	HYDROGEN	SULPHUR	OXYGEN	NITROGEN	WATER	ASH	BTU/LB
1	86	13.3	.7	0	0	0	0	19590

TEST RESULTS
****

1 TOTAL COMBUSTION AIR= 5.45533E+09 LB/HR OR 1.2123E+09 SCFM
TOTAL H20 IN FUEL GAS= 3.59313E+08 LB/HR

*******LOSSES*******

UNBURNT FUEL	UNACCOUNTABLE	RAD. LOSS	H20 & H2	DRY GAS	TOTAL	TEST
0 %	0 %	.583327 %	7.47474 %	8.8162 %	16.8743 %	(1)

O2	EX. AIR	CO	EXHAUST. TEMP.	AMB. TEMP.	BLR. LOAD	BLR. EFF.	TEST
%	%	%	DEG. F	DEG. F	LB STM/HR	%	
4.3	24.2096	0	462	70	70000	83.12	1

INDIRECT BOILER EFFICIENCY ANALYSIS

****

DESCRIPTION:GAGETOWN TEST: MAR 28, AM; FL; NO LIMESTONE; COAL ONLY
BOILER DESCRIPTION:UNIT 3
MAXIMUM RATING OF UNIT: 70000 LBS. OF STEAM/HOUR
: 67.9216 MBTU/HR
NUMBER OF WATER WALLS: 4
FUEL FIRED DURING TEST: 0
ENTHALPY RISE THRU BLR.: 7.03E+07 BTU/LB
FUEL CONSTITUENTS
****

%'S BY WEIGHT

TEST	CARBON	HYDROGEN	SULPHUR	OXYGEN	NITROGEN	WATER	ASH	BTU/LB
1	74.8	4.9	2.6	6.3	1.4	1.5	8.5	14300

TEST RESULTS
****

1 TOTAL COMBUSTION AIR= 5.04725E+09 LB/HR OR 1.12161E+09 SCFM
TOTAL H20 IN FUEL GAS= 1.80006E+08 LB/HR

*******LOSSES*******

UNBURNT FUEL	UNACCOUNTABLE	RAD. LOSS	H20 & H2	DRY GAS	TOTAL	TEST
0 %	0 %	.583327 %	3.90177 %	8.90122 %	13.3863 %	(1)

O2	EX. AIR	CO	EXHAUST. TEMP.	AMB. TEMP.	BLR. LOAD	BLR. EFF.	TEST
%	%	%	DEG. F	DEG. F	LB STM/HR	%	
3	25.1509	0	462	70	70000	86.61	1

12.0 BASELINE TEST RESULTS (CONT'D)

GAGETOWN TEST BOILER EFFICIENCY COMBINING OIL AND COAL

MORNING OF MARCH 28, 1982, FULL LOAD, NO LIMESTONE, UNIT 3

EFFICIENCY USING THE COMPUTER LISTINGS ON PREVIOUS PAGE

OVERALL BOILER LOSS.

= OIL LOSS X (BTU OIL INPUT/TOTAL BTU INPUT)

+ COAL LOSS X (BTU COAL INPUT/TOTAL BTU INPUT)

+ UNACCOUNTED FOR LOSSES

+ UNBURNED FUEL LOSSES

= $\overset{+}{16.9}\ (\overset{++}{0.0626}) + \overset{+}{13.4}\ (\overset{++}{0.9374}) + 2.6 + 0$

= 16.2 %

OVERALL BOILER EFFICIENCY = 83.8 %

EFFICIENCY USING CURVES (FROM "A COMBUSTION HANDBOOK FOR CANADIAN FUELS, VOL. 3, PART I; AND VOL. 1")

OIL WAS ASSUMED TO 7 % OF THE TOTAL (COAL & OIL) ENERGY INPUT.

OVERALL BOILER EFFICIENCY = 84.06 %

+ SEE COMPUTER LISTINGS ON PREVIOUS PAGE.

++ SEE PREVIOUS TABLE ON OIL FLOW FOR FLAME STABILIZATION.

* SEE PREVIOUS TABLE ON LIMESTONE FEEDRATES.

13.0 ACCEPTANCE TEST DETAILS AND DATA

13.1 PERFORMANCE TEST PLAN AND SCHEDULE

CFB GAGETOWN LOW NO_x/SO_x PROGRAM

DSS FILE NO. 15 SQ.23440-3-9153
CONTRACT SERIAL NO. OSQ83-00128

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DIAGRAM SHOWING LINKAGE BETWEEN LIMESTONE FEEDER AND COAL FEEDER (TO BE VERIFIED BY VOLCANO/ STEINMUELLER

ASME TEST FORM

TEST PLAN FOR RETROFIT OF LOW NO_x/SO_x BURNERS TO BE INSTALLED ON BOILER NO. 2, CFB GAGETOWN.

TWO OR THREE SETS OF TESTS WILL BE CONDUCTED. FOR THE FIRST SET OF TESTS, THERE WILL BE NO ADDITIVE TO REDUCE SO_x EMISSION.

FOR THE SECOND SET, A Ca/S MOLE RATIO OF 2.5 WILL BE ACHIEVED BY ADDING HAVELOCK LIMESTONE TO REDUCE SO_x EMISSIONS. THE THIRD MAY BE REQUIRED IF VOLCANO/STEINMUELLER WISH TO USE AN ALTERNATIVE ADDITIVE TO REDUCE SO_x (ASSUMING THE SCIENTIFIC AUTHORITY CONCURS).

FULL LOAD TESTS WILL BE CONDUCTED WITHOUT OIL SUPPORT FLAMES. IF THERE IS EVIDENCE OF UNSTABLE COMBUSTION, AN OIL FLAME SHOULD BE TURNED ON UNTIL THE PROBLEM IS RESOLVED. THIS IS PREFERABLE TO BURNER TRIPS.

IF DRY COAL FOR THE TEST CAN BE SET ASIDE IN THE COAL SHED, THE PROBABILITY OF SUCCES IN MAINTAINING STABLE COMBUSTION WITHOUT OIL WILL BE INCREASED. COAL FLOW PROBLEMS AND PULVERIZER OPERATION ARE AMONG THE POTENTIAL CAUSES OF FLAME INSTABILITY. WET COAL IS A COMMON CAUSE.

TEST PLAN (Cont'd)

THE OPERATING PEOPLE SHOULD GAIN EXPERIENCE WITH THE NEW BURNER MANAGEMENT SYSTEM WELL BEFORE THE TESTS. THIS WOULD BE WORTHWHILE WHETHER OR NOT OPERATION WITHOUT OIL ON BOILER NO. 2 BECOMES NORMAL OPERATION.

FOR ALL TESTS, ENVIRONMENT CANADA WILL BE RESPONSIBLE FOR MONITORING EMISSIONS OF SO_2*, NO_x, CO, CO_2 AND O_2. BECAUSE OF THE RISK OF INFILTRATION BETWEEN THE AIR PREHEATER OUTLET AND THE ENVIRONMENT CANADA MONITORING POINT, THERE SHOULD BE CONTINUOUS O_2 AND TEMPERATURE MEASUREMENT AT THE AIR PREHEATER OUTLET. THIS IS ESSENTIAL TO ENSURE AN ACCURATE BOILER EFFICIENCY DETERMINATION.

G.A. ROBB ASSOCIATES WILL BE RESPONSIBLE FOR COAL AND ASH SAMPLING, FOR RECORDING OPERATING DATA AND FOR BOILER EFFICIENCY DETERMINATION.

FOR TESTS WITH THE ADDITION OF LIMESTONE OR OTHER ADDITIVES, G.A. ROBB ASSOCIATES WILL BE RESPONSIBLE FOR THE

* Emission of SO_2 will be monitored by Env. Canada rather than SO_x because other SO_x components will be very scarce and hard to measure.

TEST PLAN (Cont'd)

THE ACCURACY OF THE LIMESTONE AND COAL FEEDRATE; Ca/S MOLE RATIO DETERMINATION; THE COAL, LIMESTONE AND ASH SAMPLE COLLECTION AND BOILER EFFICIENCY CALCULATIONS.

THE GUARANTEE CALLS FOR 50% REDUCTIONS IN NO_x and SO_x EMISSIONS. THE TARGETS ARE AN NO_x LEVEL OF 250 PPM AND AN SO_x OF 950 PPM. THIS TO BE ACHIEVED WITH A BOILER EFFICIENCY OF NOT LESS THAN 82% AT FULL LOAD BURNING COAL ONLY. BOILER EFFICIENCY IS TO BE DETERMINED BY THE ASME PC-4-1-64 HEAT LOSS METHOD.

THE CONTRACT REQUIRED VOLCANO/STEINMUELLER TO PROVIDE AN ACCURATE MEASUREMENT OF ADDITIVE FEEDRATE. COAL FEEDRATE WILL BE DERIVED FROM BOILER OUTPUT AND BOILER EFFICIENCY. BOILER OUTPUT IS DETERMINED BY WATER FLOW/DELTA T MEASUREMENTS. BOILER INPUT IN THERMAL UNITS IS BOILER OUTPUT DIVIDED BY BOILER EFFICIENCY. THE MASS FLOW RATED OF COAL AND SULPHUR WILL BE DETERMINED FROM THE THERMAL INPUT TO THE BOILER AND THE COAL ANALYSIS.

ACCURATE MEASUREMENT OF BOILER OUTPUT IS CRUCIAL. THUS THE SYSTEM FOR MEASURING BOILER OUTPUT SHOULD BE CALIBRATED BEFORE THE TESTS. THE ORIFICE OR FLOW NOZZLE DIAMETER SHOULD BE CHECKED IN CASE THERE HAS BEEN WEAR.

TEST PLAN (Cont'd)

VARIATIONS IN CALORIFIC VALUE OF THE FUEL WILL CAUSE SOME INACURRACY IN DETERMINATION OF MASS FLOW OF COAL. THERE WILL BE SOME VARIATION IN SULPHUR CONTENT OF THE COAL. GIVEN THE DIFFICULTY OF DIRECT COAL FLOW MEASUREMENT, THE INDIRECT APPROACH IS A PRACTICAL COMPROMISE.

TEST PROCEDURE

CALIBRATION AND CONTINUOUS MONITORING OF NO_x, SO_2, CO and O_2 BY ENVIRONMENT CANADA WILL BEGIN SEVERAL HOURS BEFORE THE START OF THE TEST DAY. THE BOILER LOAD WILL BE SET AT 70 MBTU/HR (FULL LOAD) WITH NORMAL EXCESS AIR AT THE TIME CALIBRATION AND CONTINUOUS MONITORING BEGINS.

IN ADDITION TO MONITORING GASEOUS EMISSIONS, ENVIRONMENT CANADA WILL COLLECT PARTICULATE SAMPLES FROM THEIR MONITORING POINT BEFORE THE SETTLING CHAMBER. THESE WILL BE USED TO DETERMINE COMBUSTIBLES IN THE DUST AT THE SAMPLING POINT.

THE ENVIRONMENT CANADA SAMPLING POINT IS AFTER A RELATIVELY INEFFICIENT, DECADES OLD, MECHANICAL DUST COLLECTOR BUT BEFORE THE STACK.

TEST PLAN (Cont'd)

SUBSTANTIAL AMOUNTS OF PARTICULATE ARE REMOVED BY THE MECHANICAL COLLECTOR BEFORE THE SAMPLING POINT, AND BY THE SETTLING CHAMBER WHICH IS AFTER THE SAMPLING POINT BUT BEFORE THE STACK. THUS THE PARTICULATE LOADING AT THE ENVIRONMENT CANADA SAMPLING POINT IS LESS THAN THAT LEAVING THE BOILER AND MORE THAN THAT IN THE STACK. THUS THESE SAMPLES ARE NOT DIRECTLY INDICATIVE OF EITHER STACK PARTICULATE EMISSIONS OR THE QUANTITY OF PARTICULATES LEAVING THE BOILER.

THE PARTICULATE MEASUREMENTS BY ENVIRONMENT CANADA WILL YIELD MASS FLOW RATE OF GAS WHICH WILL ENABLE THEM TO STATE GASEOUS EMISSIONS IN UNITS PER HOUR. THIS WILL ALLOW EMISSIONS TO BE STATED IN MASS UNITS PER UNIT OF BOILER OUTPUT ETC...

THE ANALYSIS OF THE PARTICULATES COLLECTED AT THE ENV. CANADA SAMPLING POINT MAY DIFFER FROM THAT OF PARTICULATES TAKEN FROM THE DUST COLLECTOR HOPPERS. THE MATERIAL PASSING THROUGH THE MECHANICAL COLLECTORS WILL TEND TO BE LIGHTER THAN THE MATERIAL FROM THE HOPPERS. ARSENIC AND SULPHATE LEVELS AS WELL AS COMBUSTIBLES WILL BE DETERMINED.

TEST PLAN (Cont'd)

ABOUT 15 MINUTES BEFORE THE BEGINNING OF EACH TEST DAY, ALL HOPPERS WILL BE EMPTIED AND SOOT BLOWERS WILL BE OPERATED BY THE BASE OPERATING STAFF. G.A. ROBB ASSOCIATES WILL ENSURE THAT TEMPERATURE AND OXYGEN READINGS ARE AVAILABLE AT THE AIR HEATER OUTLET. ANY DIFFERENCE BETWEEN PLANT RECORDERS ON THE PANEL, AND INSTRUMENTS USED FOR THE TEST WILL BE NOTED. THIS WILL MAKE THE RECORDER CHARTS A USEFUL SUPPLEMENT TO THE TEMPERATURE AND OXYGEN INDICATORS PUT IN PLACE SPECIFICALLY FOR THE TEST.

AT THE BEGINNING OF EACH TEST, G.A. ROBB ASSOCIATES WILL START COLLECTING COAL SAMPLES AT THE PULVERIZER INLETS.

FOR FULL LOAD TESTS WITH 2 PULVERIZERS, ONE SAMPLE WILL BE TAKEN EVERY 15 MINUTES FROM ALTERNATE PULVERIZER INLETS. THUS THERE WILL BE ONE SAMPLE EVERY HALF HOUR FROM A GIVEN PULVERIZER. THE SAMPLES WILL BE TAKEN FROM THE OPEN FUNNEL ABOVE THE PULVERIZER USING A SMALL SHOVEL AND PUT IN PLASTIC BAGS IN METAL CONTAINERS.

ALSO AT THE BEGINNING OF EACH TEST, G.A. ROBB ASSOCIATES WILL BEGIN RECORDING PANEL DATA PLUS THE SPECIAL

TEST PLAN (Cont'd)

TEMPERATURE AND OXYGEN READINGS AT THE AIR PREHEATER OUTLET. READINGS TO BE AT 15 MINUTE INTERVALS. PHOTO COPIES OF RECORDER CHARTS WILL BE RETAINED.

THE FOLLOWING READINGS WILL BE RECORDED BY G.A. ROBB ASSOCIATES:

BOILER LOAD	MW (THERMAL)
BOILER WATER	OUTLET PRESSURE
	OUTLET TEMPERATURE
	INLET TEMPERATURE
	% FLOW
COMBUSTION AIR TEMP.	OUTDOOR
	AMBIENT (ROOM)
	AIR HEATER IN
	AIR HEATER OUT
	PRIMARY TOP
	PRIMARY BOTTOM
COMBUSTION AIR FLOW	% OF FULL RATE
GAS TEMPERAUTRE	AIR HEATER IN
	AIR HEATER OUT (PANEL)
	AIR HEATER OUT (PORTABLE)
O_2 AIR HEATER OUTLET	PANEL
	PORTABLE

TEST PLAN (Cont'd)

OIL INPUT - METER READS IN LITRES - TAKE READING EVERY 15 MINUTES (THE DIFFERENCE BETWEEN THE FIRST AND SECOND READINGS REPRESENTS CONSUMPTION).

PULVERIZER LOAD	TOP AMPS
	BOTTOM AMPS
PULVERIZER DRAFT	TOP PULVERIZER
	BOTTOM PULVERIZER
SMOKE DENSITY	%
WINDBOX PRESSURE	
FURNACE DRAFT	Pa
LIMESTONE FLOW RATE	

ADDITIONAL READINGS WHICH MAY BE PART OF THE VOLCANO/STEINMUELLER INSTALLATION.

G.A. ROBB ASSOCIATES WILL BE RESPONSIBLE FOR OBTAINING A COAL SAMPLE FROM EACH PULVERIZER OUTLET EVERY HOUR. THESE WILL BE TAKEN AT 30 MINUTE INTERVALS FROM ALTERNATE PULVERIZERS. THE SAMPLES WILL BE PLACED IN A PLASTIC BAG IN A PAIL.

FOR TESTS WITH LIMESTONE OR OTHER ADDITIVE ADDITION, G.A. ROBB ASSOCIATES WILL OBTAIN ONE LIMESTONE SAMPLE FROM THE

TEST PLAN (Cont'd)

FEEDSTREAM EVERY 15 MINUTES. THESE SAMPLES WILL BE PUT IN A PLASTIC BAG INSIDE A PAIL.

ABOUT 15 MINUTES BEFORE THE END OF EACH TEST, G.A. ROBB ASSOCIATES WILL COLLECT ASH SAMPLES FROM THE COLLECTOR HOPPERS AND THE FURNACE BOTTOM. THESE WILL BE PUT IN BUCKETS UNTIL COOL, THEN TRANSFERRED TO PLASTIC BAGS AND PUT IN CONTAINERS.

APPENDIX "A" OF ROBB REPORT

SPECIFICATIONS

1. PERFORMANCE REQUIREMENTS

1.1 THE RETROFIT BURNERS AND CALCIUM INJECTION SYSTEM SHALL BE A COMPLETE PACKAGE COMPATIBLE WITH THE EXISTING BOILER, ANCILLARIES AND AVAILABLE SPACE.

1.2 THE INTEGRATED BURNER AND ADDITIVE SYSTEM TO BE DEVELOPED AND SUPPLIED SHALL BE GUARANTEED TO MEET THE FOLLOWING REQUIREMENTS:

a) NITROGEN OXIDE AND SULPHUR DIOXIDE LEVELS SHALL BE REDUCED BY 50% OR MORE WITHOUT SUPPORT FIRING AT FULL LOAD IN BOILER NO. 2 WHILE BURNING THE COAL SPECIFIED IN ANNEX 1 WITH HAVLEOCK LIMESTONE INJECTION. THE LIMESTONE ADDITION RATE SHALL NOT EXCEED A Ca/S MOL RATIO OF 2.5 TO ACHIEVE THE SPECIFIED LEVEL OF SO_x REDUCTION. FOR PURPOSES OF THIS REQUIREMENT THE NO_x LEVEL IS CONSIDERED TO BE 500 PPM CORRECTED TO 3% OXYGEN AND THE SO_x LEVEL IS CONSIDERED TO BE 1900 PPM CORRECTED TO 3% OXYGEN. THUS, THE NO_x TARGET IS 250 PPM CORRECTED TO 3% OXYGEN AND THE SO_x

APPENDIX "A" (Cont'd)

TARGET IS 950 PPM CORRECTED TO 3% OXYGEN. NO_x AND SO_x LEVELS WILL BE DETERMINED BY ENVIRONMENT CANADA EPS METHODS, EPS-1-AP-77-3 and EPS-1-AP-74-3 RESPECTIVELY.

b) WHILE OPERATING AT FULL LOAD ON COAL ONLY, WITH COMBUSTION AIR AND CALCIUM SET TO PROVIDE THE GUARANTEED NO_x AND SO_x LEVELS, THE BOILER EXIT TEMPERATURE SHALL NOT EXCEED 390°C WITH SOOT-BLOWING AT CONSECUTIVE FOUR (4) HOUR INTERVALS.

i) THE FLAME LENGTH SHALL NOT EXCEED THOSE IN CURRENT OPERATION; IMPINGEMENT OF FLAME ON BOILER SIDE, FRONT OR BACK WALLS IS UNACEPTABLE.

ii) THE FIRESIDE DEPOSITS IN THE BOILER SHALL REMAIN DRY AND BE REMOVABLE WITH THE EXISTING SOOT BLOWERS; SLAGGING OR FOULING OF BOILER SURFACES MUST NOT OCCUR.

iii) COMBUSTIBLE IN FLYASH SHALL NOT EXCEED 7% BY WEIGHT BEFORE THE SETTLING CHAMBER COLLECTOR.

APPENDIX "A" (Cont'd)

iv) COMBUSTION EFFICIENCY AS DETERMINED BY THE ASME PTC-4.1-1964 HEAT LOSS METHOD SHALL NOT BE LESS THAN 82% AT FULL LOAD ON COAL ONLY.

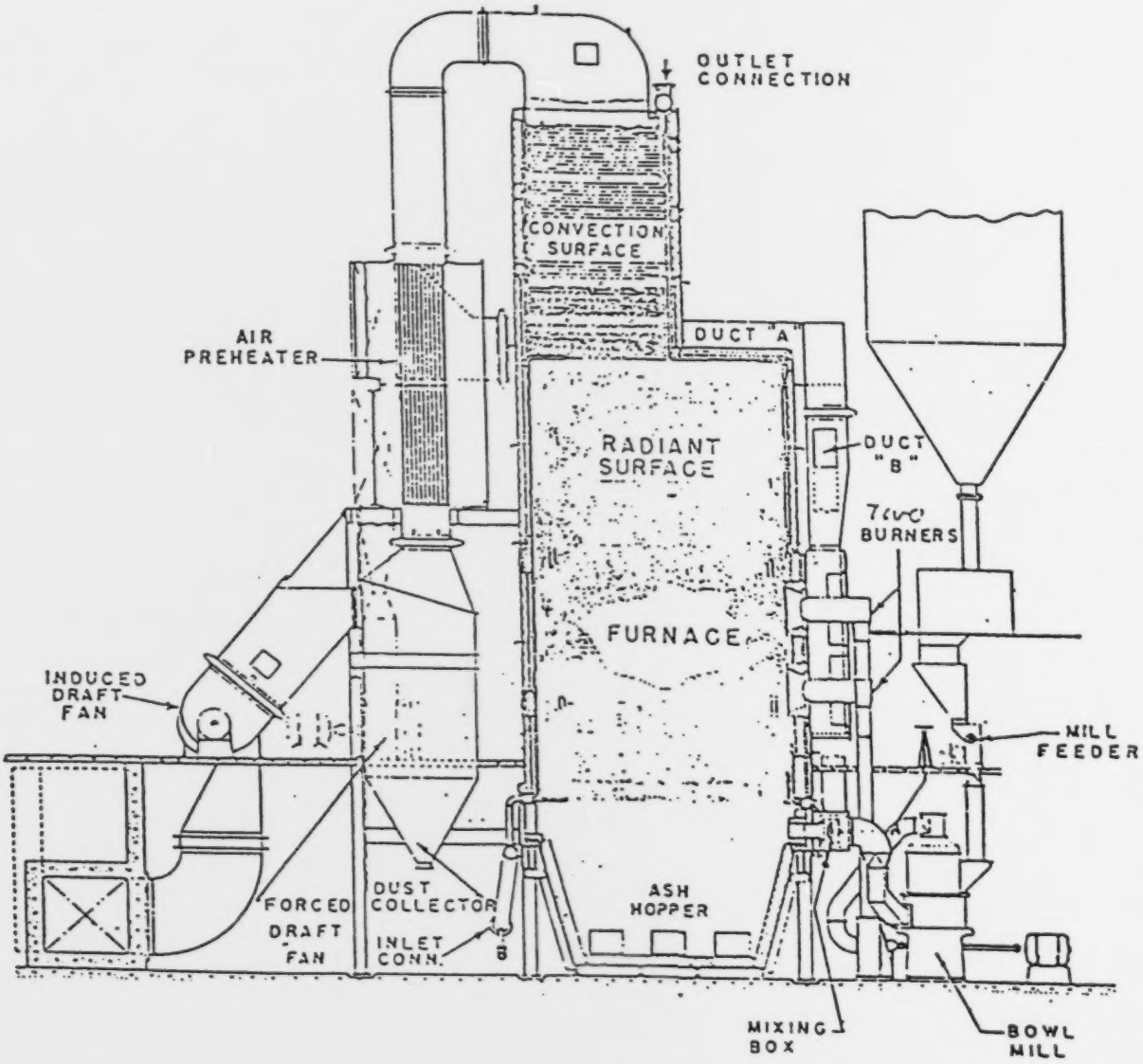

OUTLET CONNECTION
CONVECTION SURFACE
DUCT "A"
AIR PREHEATER
RADIANT SURFACE
DUCT "B"
Two BURNERS
FURNACE
INDUCED DRAFT FAN
MILL FEEDER
FORCED DRAFT FAN
DUST COLLECTOR
INLET CONN.
ASH HOPPER
MIXING BOX
BOWL MILL

FIGURE A-1

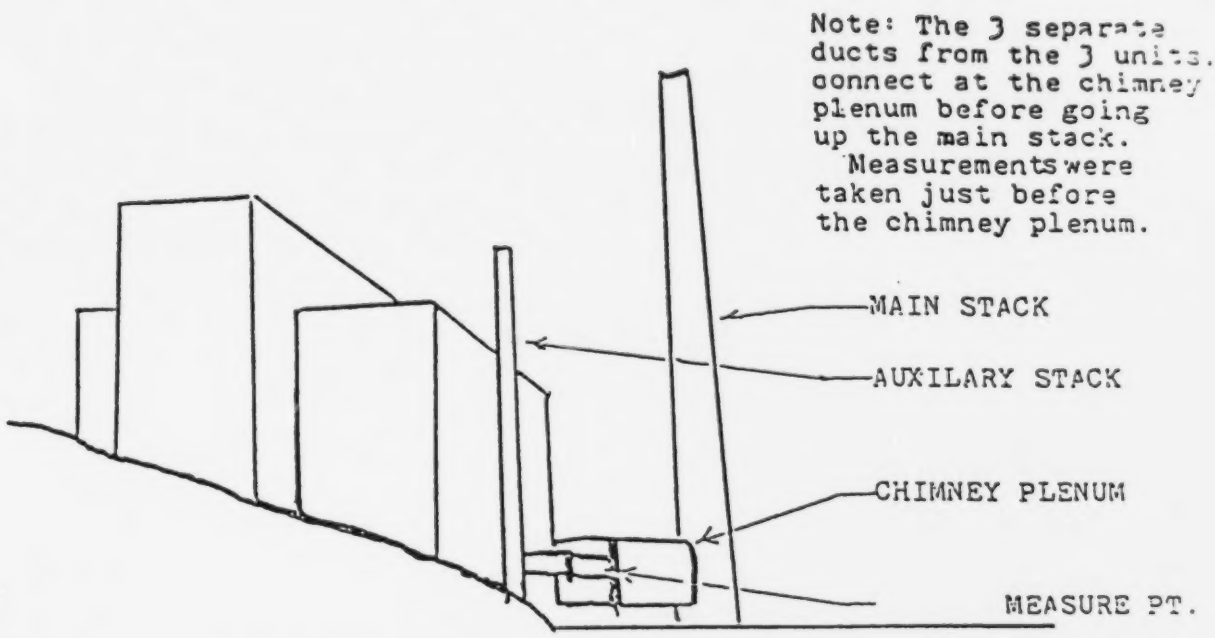

Note: The 3 separate ducts from the 3 units connect at the chimney plenum before going up the main stack. Measurements were taken just before the chimney plenum.
MAIN STACK
AUXILARY STACK
CHIMNEY PLENUM
MEASURE PT.

Fig. 4.1a: OUTSIDE VIEW OF PLANT AND ENVIRONMENT CANADA MEASUREMENT POINT.

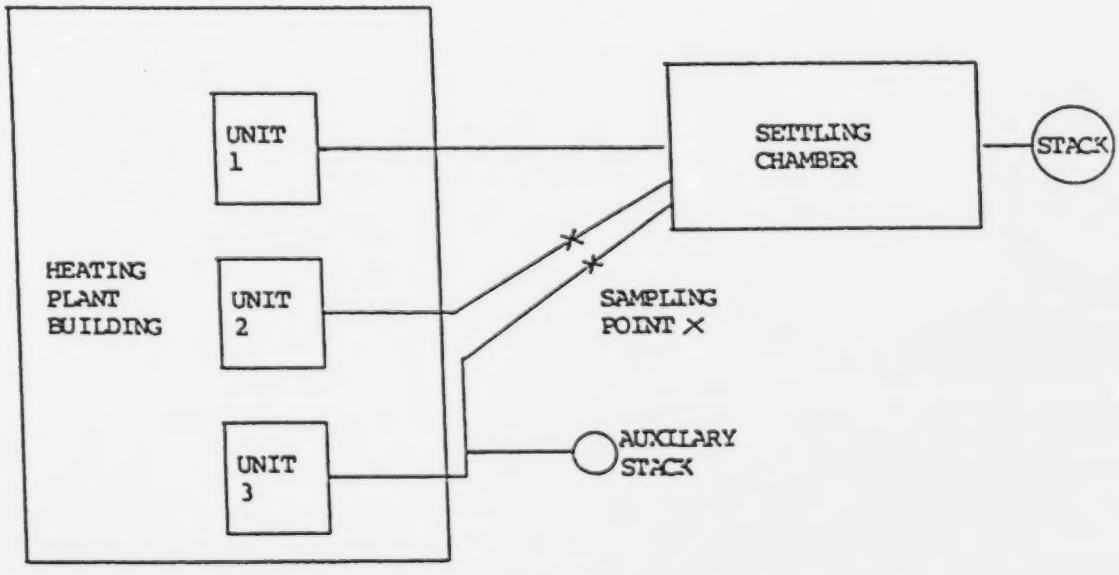


Fig. 4.1b: PLAN VIEW OF ENVIRONMENT CANADA MEASUREMENT POINT

SURVEY PROPOSAL

A STACK SAMPLING PROGRAM TO MEASURE THE EMISSIONS OF SO_2, NO_x, CO, CO_2 AND O_2 AND TO CHARACTERIZE PARTICULATE EMISSIONS FROM THE CFB GAGETOWN CENTRAL HEATING PLANT

Prepared by:

SOURCE MONITORING UNIT
POLLUTION MEASUREMENT DIVISION
TECHNICAL SERVICES BRANCH
ENVIRONMENTAL PROTECTION PROGRAMS DIRECTORATE

SEPTEMBER 1983

1. INTRODUCTION

IN LATE MARCH 1982, A STACK SAMPLING PROGRAM WAS CONDUCTED AT THE CENTRAL HEATING PLANT OF CFB GAGETOWN. THESE TESTS WERE CONDUCTED TO ESTABLISH BASELINE LEVELS OF NO_x AND SO_2 PRIOR TO THE RETROFIT OF LOW NO_x BURNERS. UNFORTUNATELY, DUE IN PART TO THE BOILER FAILURE DURING THE 1982 BASELINE TESTS AND THE SWITCHOVER TO A DIFFERENT COAL IN THE 1983/1984 HEATING SEASON, REPRESENTATIVES FROM EM&R AND DOE HAVE DECIDED TO REPEAT THE BASELINE TEST PROGRAM. THE BASELINE STUDY HAS BEEN SCHEDULED TO BEGIN IN EARLY OCTOBER TO ALLOW RETROFITTING OF THE BOILER IN THIS FISCAL YEAR.

THE GAGETOWN HEATING PLANT CONSISTS OF THREE COMBUSTION ENGINEERING HOT WATER BOILERS. EACH BOILER IS RATED AT 70 MMBTU/HR AND IS EQUIPPED WITH TWO CE TYPE RO FRONT-MOUNTED PULVERIZED COAL BURNERS. NUMBER 2 BOILER HAS BEEN IDENTIFIED FOR THE BASELINE STUDY. FOUR TEST CONDITIONS WILL BE INVESTIGATED i.e. 50% AND 100% LOAD WITH AND WITHOUT LIMESTONE.

THIS PROPOSAL WILL IDENTIFY THE PMD TASKS AND OUTLINE THE SAMPLING METHODOLOGIES AND SAMPLING SCHEDULE.

SURVEY PROPOSAL (Cont'd)

2. SAMPLING

2.1 CONTINUOUS METHODS

THE GAS SAMPLE FOR THE CONTINUOUS MONITORS WILL BE EXTRACTED FROM A 4 INCH PORT LOCATED UPSTREAM OF THE SETTLING CHAMBER ON THE NO. 2 BOILER FLUE (1700 mm x 914 mm) (Figure 1). FOLLOWING CONDITIONING OF THE SAMPLE GAS TO REMOVE PARTICULATE AND MOISTURE, THE COOLED DRIED GAS IS THEN PUMPED TO THE CONTINUOUS MONITORS FOR NO_x, SO_2, CO and O_2 ANALYSIS (Figure 2). A DESCRIPTION OF THESE MONITORS IS GIVEN IN TABLE I.

FIGURE 1 - NO. 2 BOILER FLUE - LOCATION OF SAMPLING PORTS

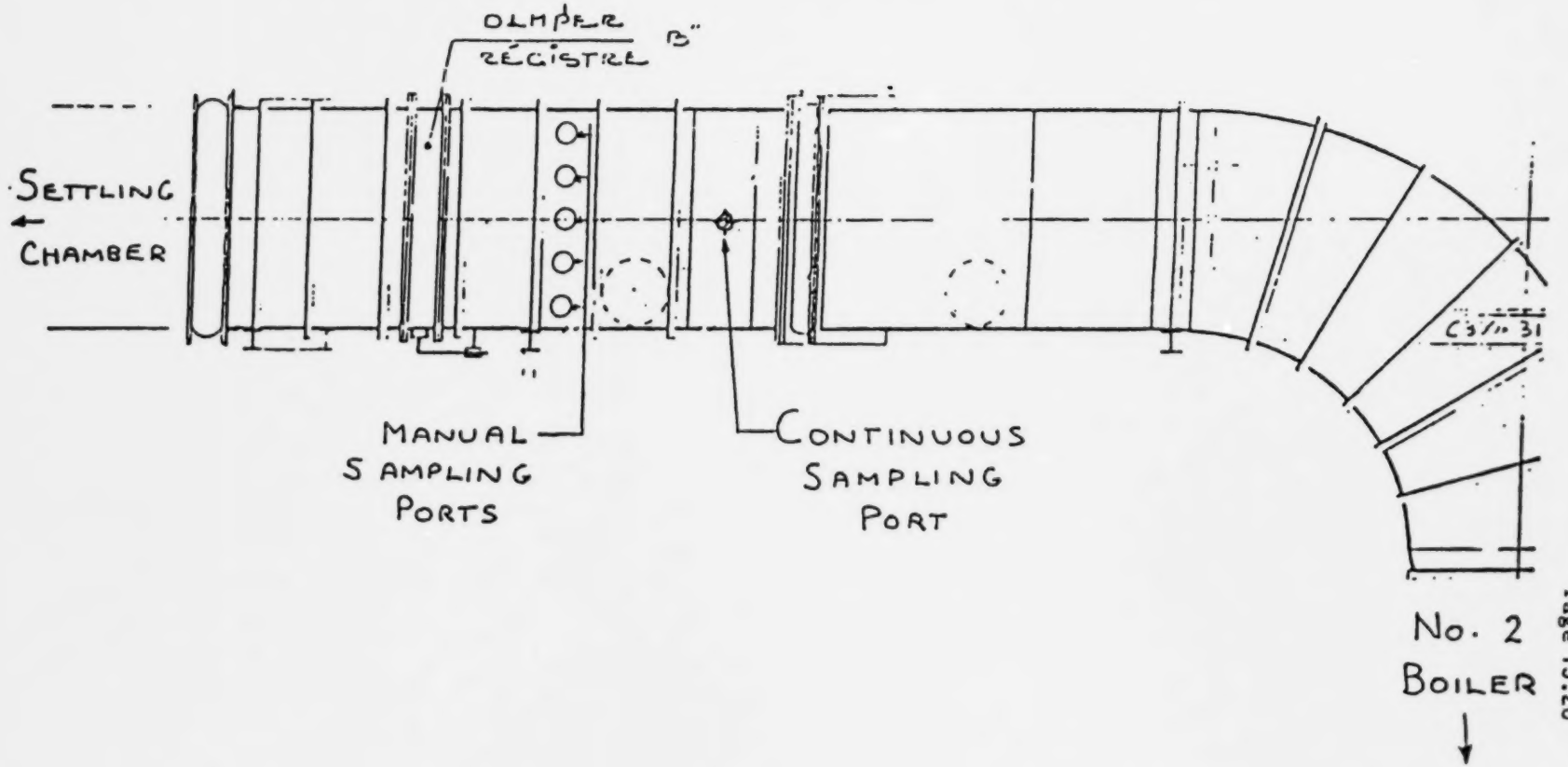
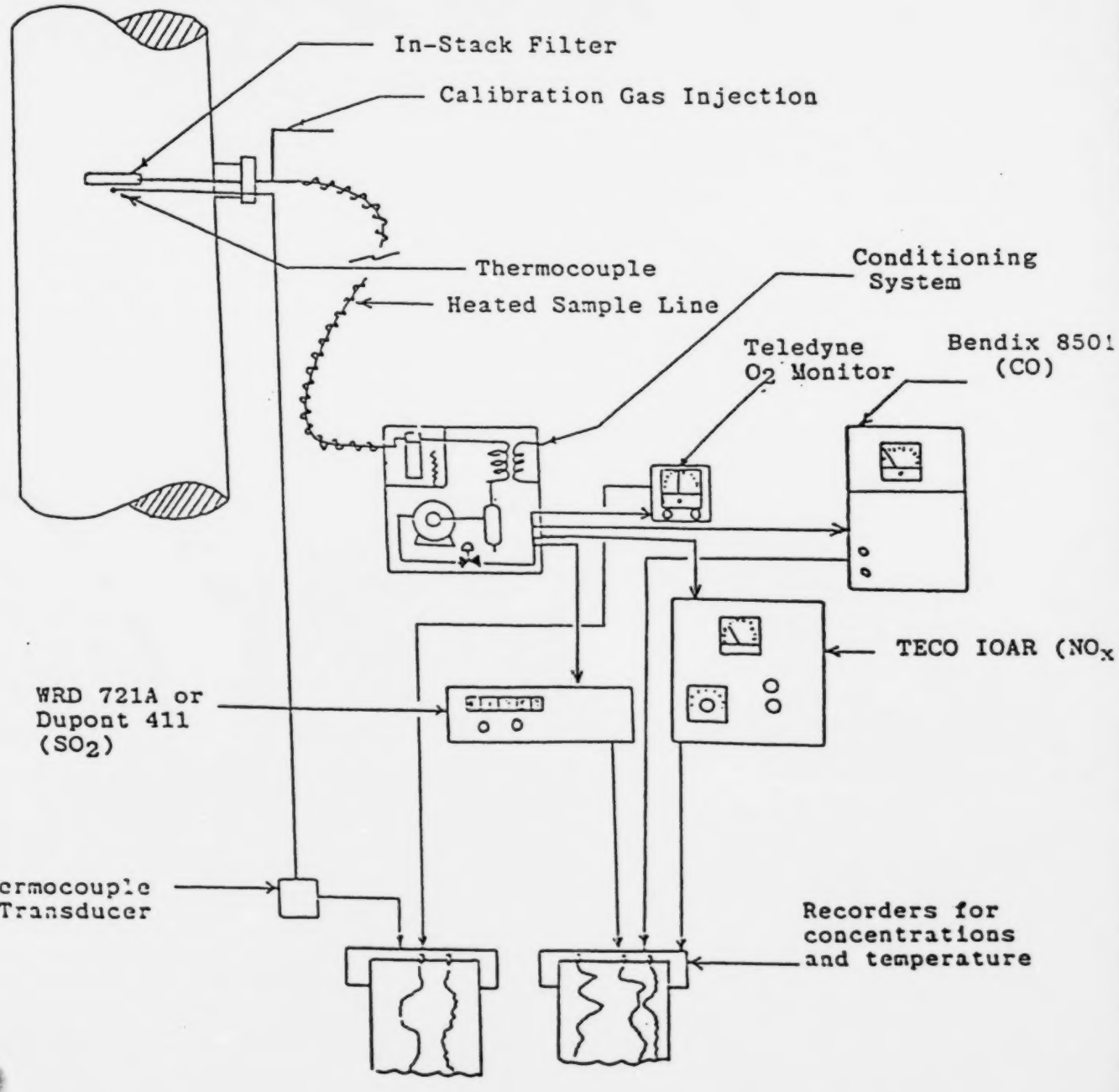


FIGURE 2 - CONTINUOUS SOURCE MONITORING SYSTEM
CFB GAGETOWN, 1983



SURVEY PROPOSAL (Cont'd)

TABLE 1 - DESCRIPTION OF THE CONTINUOUS MONITORS

TYPE	PRINCIPLE	ANALYSIS
TECO 10AR	CHEMILUMINESCENCE	NO_x
WR 721A	NONDISPERSIVE ULTRAVIOLET	SO_2
BENDIX 8501	NONDISPERSIVE INFRARED	CO
TELEDYNE 320	PARAMAGNETIC	O_2

THE SYSTEM WILL BE CALIBRATED SEVERAL TIMES DAILY. THE CALIBRATION GASES WILL BE INJECTED IMMEDIATELY AFTER THE SAMPLE PROBE SO THAT THE WHOLE SYSTEM IS CALIBRATED. ALL CONCENTRATION AND TEMPERATURE DATA WILL BE RECORDED ON CHART RECORDERS.

IN ADDITION TO THE CONTINUOUS ANALYSES DESCRIBED ABOVE, INTERMITTENT ANALYSES WILL ALSO BE PERFORMED ON THE SAMPLE GAS FOR O_2, CO_2 AND CO USING A GAS PARTITIONER.

2.2 MANUAL SAMPLING

MANUAL STACK SAMPLING PROCEDURES WILL BE APPLIED FOR THE DETERMINATION OF PARTICULATE AND ARSENIC EMISSIONS AND THE CHARACTERIZATION OF SULPHATES AND COMBUSTIBLES. THE FLUE GAS SAMPLES WILL BE COLLECTED FROM FIVE PORTS (Figure 1) USING MULTI-POINT

SURVEY PROPOSAL (Cont'd)

ISOKINETIC SAMPLING. SAMPLING DURATION WILL BE APPROXIMATELY 2 HOURS. THE APPLICATION OF THESE METHODS WILL ALSO PROVIDE THE FLUE GAS VOLUMETRIC FLOWRATE WHICH IS REQUIRED FOR THE DETERMINATION OF THE NO_x AND SO_2 MASS EMISSION RATES.

TWO RUNS (ARSENIC/SULPHATE, COMBUSTIBLES) WILL BE CONDUCTED PER TEST CONDITION. ONE RUN USING THE STANDARD PARTICULATE TRAIN WILL COLLECT A BULK SAMPLE FOR THE ANALYSIS OF COMBUSTIBLES IN THE DUST. THE RECOVERY PROCEDURES AND THE SAMPLING TRAIN ARE SHOWN IN FIGURE 3. THE OTHER RUN WILL USE THE PROPOSED ARSENIC METHOD FROM NON-FERROUS SMELTERS TO TEST FOR WATER-SOLUBLE SULPHATES IN THE PARTICULATE AND TOTAL ARSENIC (FRONT-HALF AND BACK-HALF) IN THE TRAIN. THIS METHOD IS SHOWN IN FIGURE 4. PARTICULATE LOADINGS WILL ALSO BE DETERMINED IN EACH OF THE RUNS DESCRIBED ABOVE.

THE SO_2 AND NO_x MANUAL SAMPLING TRAINS WILL ALSO BE AVAILABLE IN CASE A BACK-UP IS REQUIRED FOR THE CONTINUOUS MONITORS.

SURVEY PROPOSAL (Cont'd)

2.3 PLANT DATA AND SAMPLES

GEORGE LEE OF EM&R WILL HIRE A CONTRACTOR TO COLLECT THE COAL, LIMESTONE AND CYCLONE AND BOTTOM ASH SAMPLES AS WELL AS DOCUMENT THE PLANT OPERATION DURING THE TESTING. THIS CONTRACTOR WILL ALSO SERVE AS THE COORDINATOR BETWEEN THE PLANT AND THE PMD CREW.

3. SCHEDULING

THE SAMPLING PROGRAM HAS BEEN SCHEDULED FOR THE PERIOD 16 OCTOBER - 23 OCTOBER, 1983. IT IS EXPECTED THAT THE SURVEY WILL FOLLOW THE SCHEDULE SHOWN BELOW.

SURVEY SCHEDULE

Sunday	October 15	Travel
Monday	October 16	Travel, Set-Up
Tuesday	October 17	Test A1, Test A2
Wednesday	October 18	Test A2, Test A2
Thursday	October 19	Test B1, Test B1
Friday	October 20	Test B2, Test B2
Saturday	October 21	Contingency, Pack-Up
Sunday	October 22	Traval
Monday	October 23	Travel

SURVEY PROPOSAL (Cont'd)

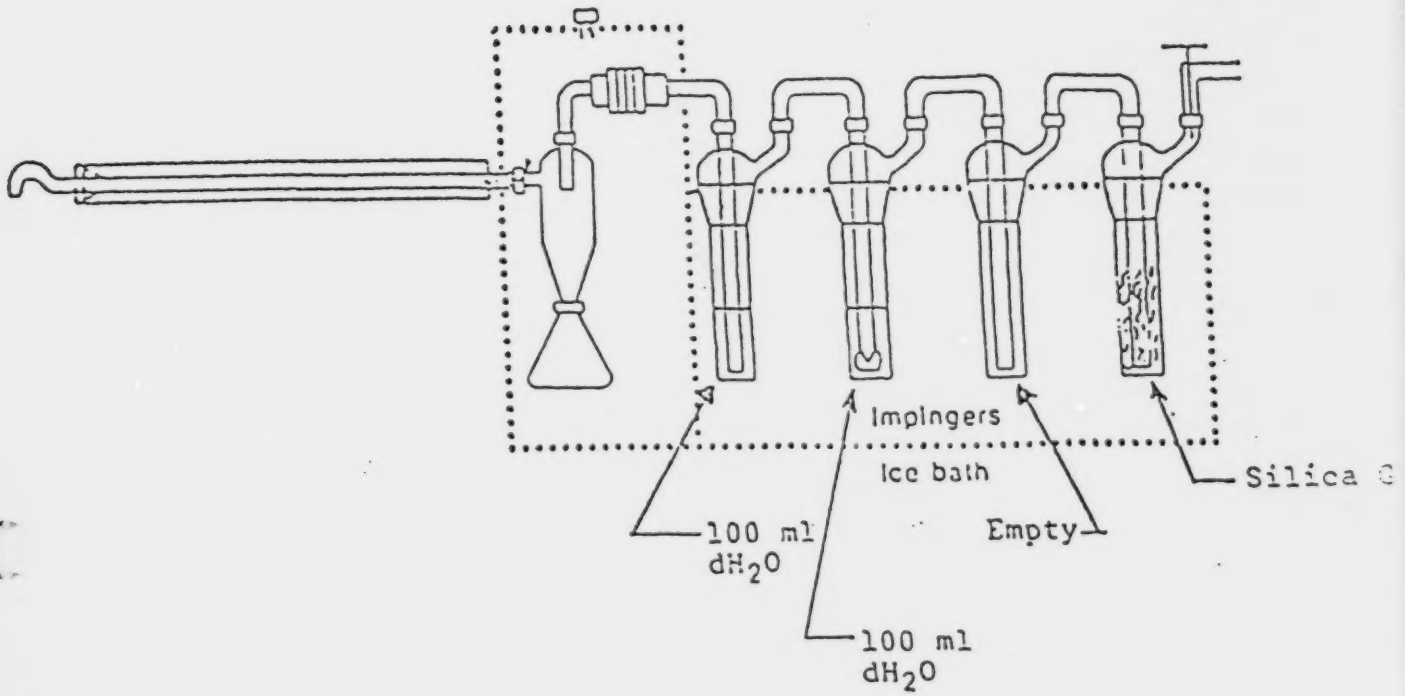
THE SURVEY SCHEDULE OUTLINED ABOVE IS TENTATIVE AND MAY BE ADJUSTED TO ACCOUNT FOR PLANT UPSETS OR BREAKDOWN OF THE SAMPLING EQUIPMENT.

NOTE: FOUR TEST CONDITIONS

A1 - 100% LOAD W/O LIMESTONE B1 - 100% LOAD W LIMESTONE

A2 - 50% LOAD W/O LIMESTONE B2 - 50% LOAD W LIMESTONE

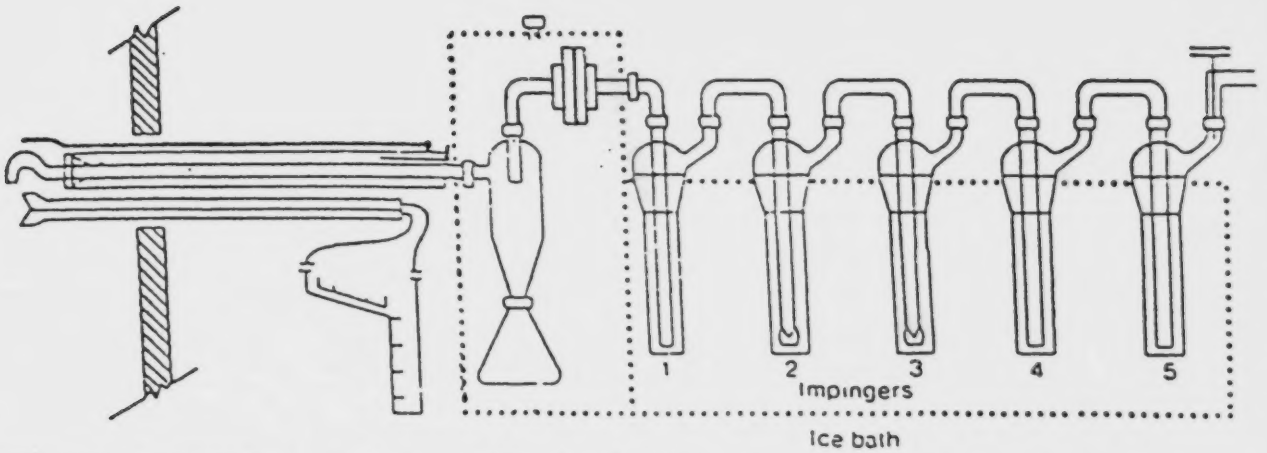
FIGURE 3 - PARTICULATE/COMBUSTIBLES SAMPLING METHOD



SAMPLE PARTITIONING AND RECOVERY PROCEDURES

	SAMPLE NO.	ITEM	PROCEDURE
FRONT HALF	1	Nozzle, Probe, F-H Holder	Wash and brush with acetone into a sample bottle. Rinse with acetone into same bottle.
	2	Filter	Replace in original petri-dish and seal for subsequent desiccation and weighing.

FIGURE 4 - ARSENIC/SULPHATE SAMPLING METHOD



Impinger Contents: 1,2,3 - 150 mL 5% HNO_3; 4 - Empty; 5 - Silica Gel

SAMPLE PARTITIONING AND RECOVERY PROCEDURES

	SAMPLE NO.	ITEM	PROCEDURE
FRONT-HALF	1	Nozzle, Probe Cyclone, F-H of Filter Holder	-Wash and brush with acetone
	2	"	-Fill with 5% NaOH, soak 5 min., dump, dH_2O rinse -Fill with 5% HNO_3, soak 5 min., dump, dH_2O rinse
	3	"	-Rinse with 5% NaOH, 5% HNO_3 and dH_2O
	4	Filter	-Place in petri dish and seal
BACK-HALF	5	B-H Filter Holder, Connector, 1st Impinger	-Empty contents in sample bottle -Rinse with 5% NaOH, 5% HNO_3 and dH_2O
	6	2nd Impinger	-As above
	7	3rd & 4th Impinger	-As above
	8	Silica Gel	-Empty contents in sample bottle
	9	B-H Glassware	-Rinse with 5% NaOH, 5% HNO_3 and dH_2O

SURVEY PROPOSAL (Cont'd)

4. QUALITY ASSURANCE

THE STACK SAMPLING TRAIN WILL BE CALIBRATED BEFORE AND AFTER THE SURVEY. TRAIN COMPONENTS REQUIRING CALIBRATION ARE:

(1) NOZZLE DIAMETER (Nd)
(2) PITOT TUBE COEFFICIENT (Cp)
(3) DRY GAS METER FACTOR (Y)
(4) ORIFICE CONSTANT (Ko)
(5) TEMPERATURE GAUGES
(6) BAROMETER

UPON COMPLETION OF THE SURVEY, ALL DATA WILL BE REVIEWED FOR CONTINUITY OF CONSTANTS AND ACCURACY OF CALCULATIONS.

5. ANALYSIS

ALL SAMPLES FROM THE ARSENIC/SULPHATE AND COMBUSTIBLES TRAINS WILL BE LABELLED, SEALED AND RETURNED TO OTTAWA. FOLLOWING DETERMINATION OF THE TOTAL PARTICULATE LOADINGS, THESE SAMPLES WILL BE FORWARDED TO THE ANALYTICAL SERVICES DIVISION AND EM&R FOR THE ANALYSIS OF ARSENIC, SULPHATES AND COMBUSTIBLES.

SURVEY PROPOSAL (Cont'd)

6. REPORT

A DATA TRANSMITTAL REPORT CONTAINING THE CONTINUOUS AND TRAVERSE RESULTS AND THE ARSENIC AND SULPHATE ANALYSES WILL BE PREPARED BY THE POLLUTION MEASUREMENT DIVISION AND PASSED ON TO G. LEE OF EM&R.

13.2 LIMESTONE AND COAL REQUIREMENTS FOR THE GAGETOWN NO_x/SO_x REDUCTION PROGRAM

WHAT FOLLOWS ARE CALCULATIONS OF THE COAL FEEDRATE REQUIRED TO MAINTAIN FULL LOAD (20 MW) AND THE CORRESPONDING LIMESTONE REQUIREMENT FOR A GIVEN CALCIUM/SULPHUR MOLE RATIO. THE ORIGINAL NOVA SCOTIA COAL AND THE KENTUCKY COAL, LATTER CONTRACTED FOR BY GAGETOWN, WERE CONSIDERES.

THE FOLLOWING PAGES GIVE THE COAL AND LIMESTONE REQUIREMENTS FOR THE ASSUMED BASE COAL SULPHUR CONTENTS, Ca/S RATIO AND CaCO3 CONTENT IN THE LIMESTONE; AS WELL AS GRAPHS OF REQUIREMENTS WHEN OTHER ASSUMPTIONS ARE MADE.

SUMMARY OF COAL AND LIMESTONE REQUIREMENTS FOR THE TEST PERIOD

Nova Scotia Coal
- 2.7% Sulphur Coal (wet basis), 2.5 Ca/S Ratio,
12885.6 BTU/lb (29970 KJ/kg) Coal (HHV wet basis),
82% 'Boiler' Efficiency and a 20 MW full load output

	Limestone		Coal	
	Lb.	Kg.	Lb.	Kg.
3, 8 Hour Full Load Tests	40,005	18,146	155,046	70,328
2, 8 Hour Hald Load Tests	13,335	6,049	51,682	23,443
TOTAL	53,340	24,195	206,728	93,771

Kentucky Coal
- 1.77% Sulphur Coal (wet basis), 2.5 Ca/S Ratio,
11690 BTU/lb (27189 KJ/kg) Coal (HHV wet basis),
82% 'Boiler' Efficiency and a 20 MW full load output

	Limestone		Coal	
	Lb.	Kg.	Lb.	Kg.
3, 8 Hour Full Load Tests	23,791	10,792	179,904	77,522
2, 8 Hour Half Load Tests	7,930	3,597	56,968	25,841
TOTAL	31,721	14,389	227,872	103,363

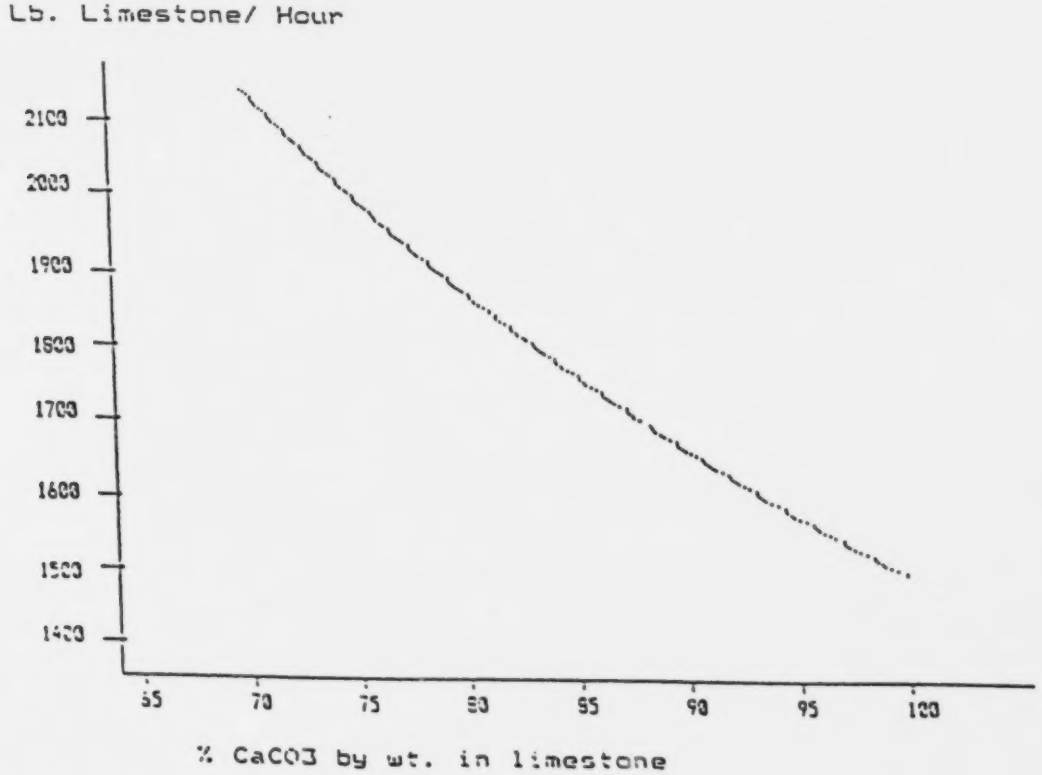
NOVA SCOTIA COAL

Lb. of limestone per Hour against % CaCO3 by weight in Limestone

Assumed Coal Analysis by weight

Carbon	.6768
Hydrogen	.0432
Sulphur	.027
Nitrogen	.0126
Ash	.09
Oxygen	.0504
Moisture	.1

- 2.7% Sulphur Coal on a wet basis (3% dry) and a Ca/S Ratio of 2.5
- 12985.6 BTU/lb Coal (HHV Wet Basis)
- a Boiler Efficiency of 82% and an Output of 20 MW



Base Case is 90% CaCO3 Limestone giving 1666.86Lb of Limestone per hr. and 5650.23Lb of Coal per hour.

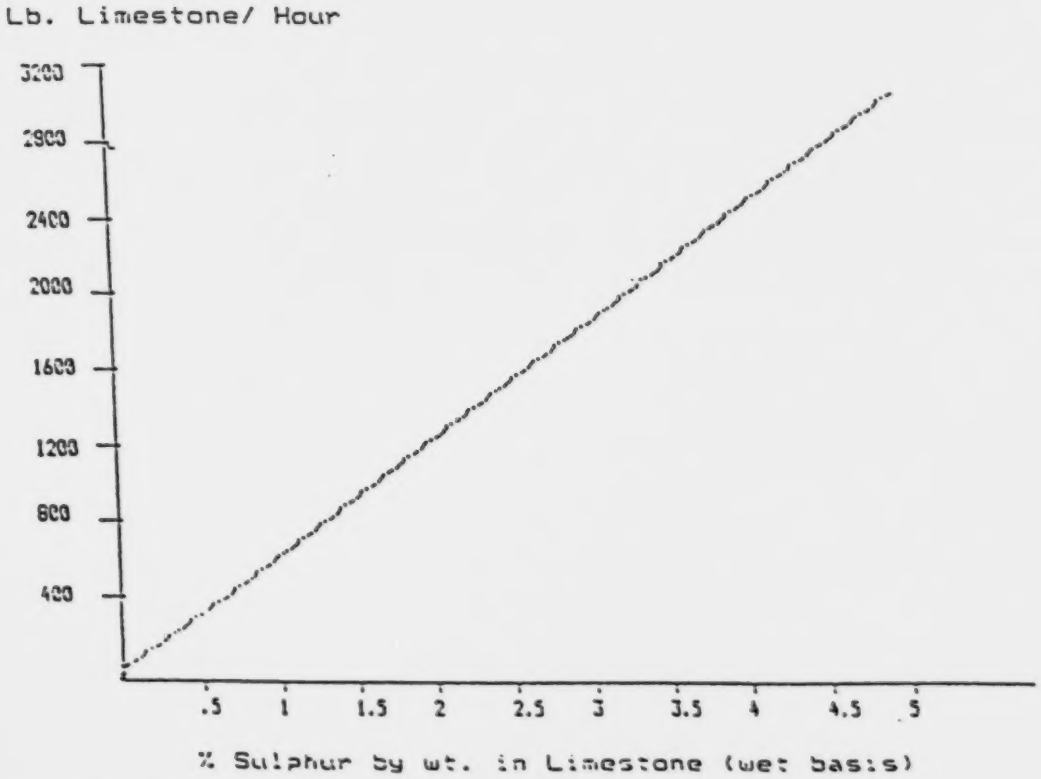
NOVA SCOTIA COAL

Lb. of limestone per Hour against % Sulphur by weight in Coal

Assumed Base Coal Analysis by weight

Carbon	.6768
Hydrogen	.0432
Sulphur	.027
Nitrogen	.0126
Ash	.09
Oxygen	.0504
Moisture	.1

- 90 % CaCO3 Limestone by wt. and a Ca/S Ratio of 2.5
- 12885.6 BTU/lb Coal (HHV Wet Basis)
- a Boiler Efficiency of 82% and an Output of 20 MW



Base Case is 2.7% (3% dry) Sulphur Coal and 1666.9 Lb of Limestone per hr. 8460.2 Lb of Coal/hr.

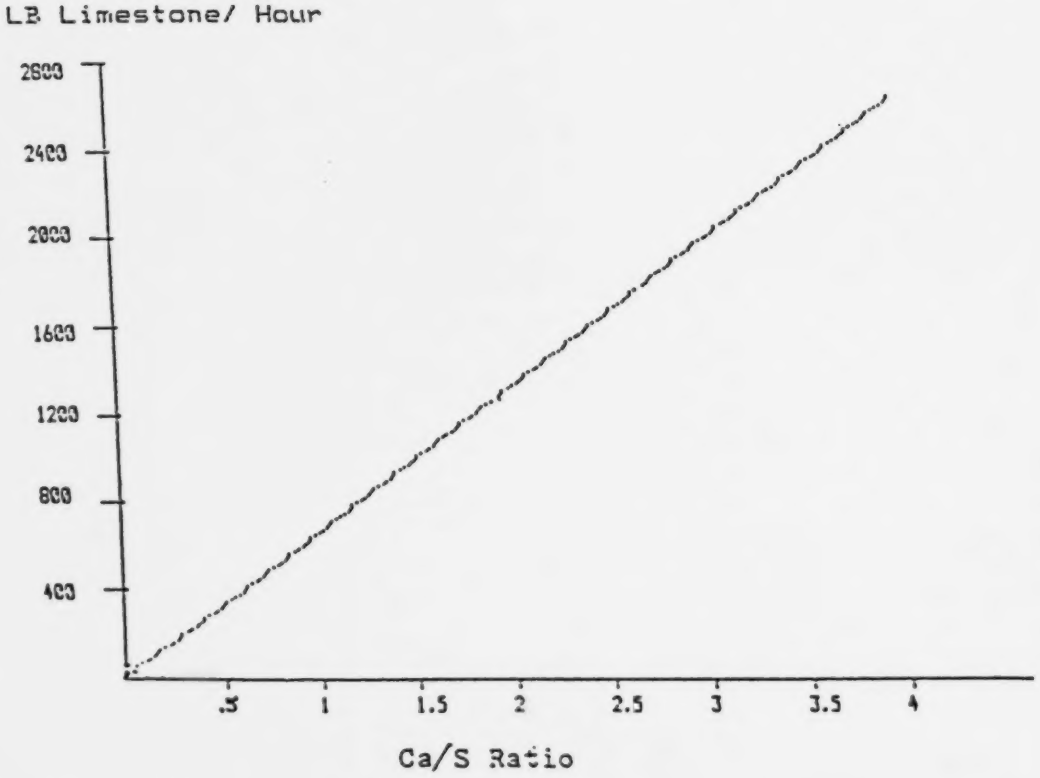
NOVA SCOTIA COAL

LB of limestone per Hour against Ca/S Ratio

Assumed Coal Analysis by weight

Carbon	.6768
Hydrogen	.0432
Sulphur	.027
Nitrogen	.0126
Ash	.09
Oxygen	.0504
Moisture	.1

- 2.7% Sulphur Coal on a wet basis (3% dry) and a Ca/S Ratio of 2.5
- 12885.6 BTU/lb Coal (HHV Wet Basis)
- a Boiler Efficiency of 82% and an Output of 20 MW



Base Case is a Ca/S Ratio of 2.5 and 1666.86 Lb of Limestone per hr. and 6460.23 lb of Coal per hour.

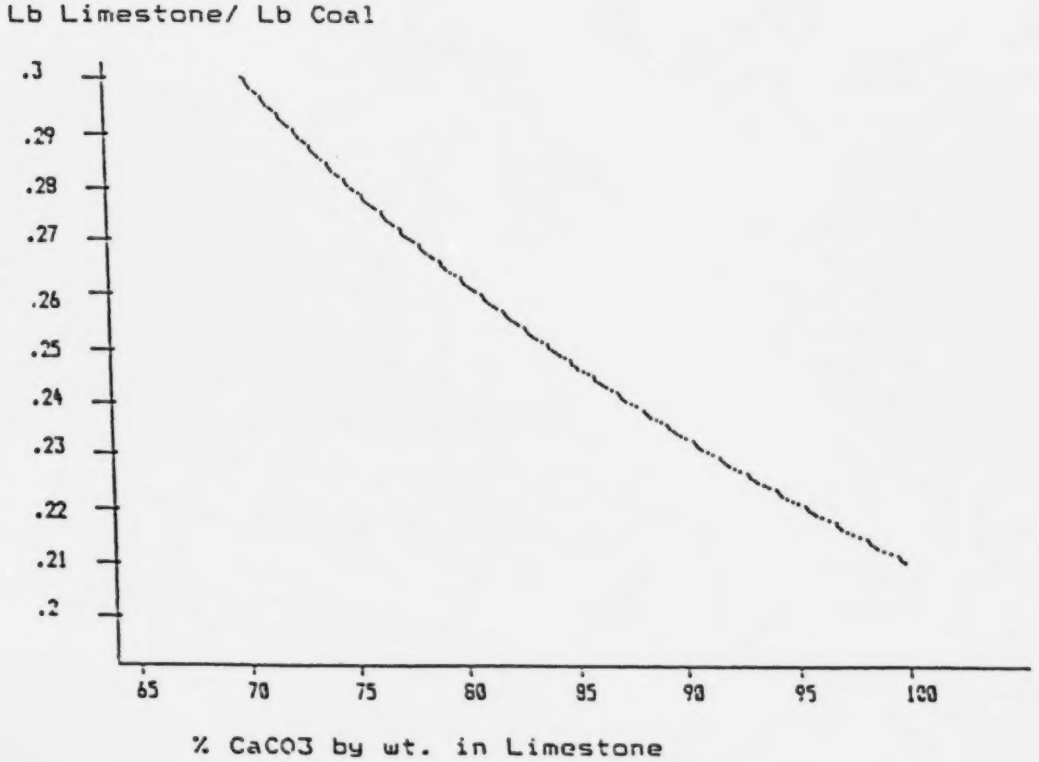
NOVA SCOTIA COAL

Lb. of limestone per Lb of Coal against % CaCO3 by weight in Limestone"

Assumed Coal Analysis by weight

Carbon	.6768
Hydrogen	.0432
Sulphur	.027
Nitrogen	.0126
Ash	.09
Oxygen	.0504
Moisture	.1

- 2.7% Sulphur Coal on a wet basis (3% dry) and a Ca/S Ratio of 2.5
- 12885.6 BTU/lb Coal (HHV Wet Basis)
- a Boiler Efficiency of 82% and an Output of 20 MW



Base Case is 90% CaCO3 Limestone giving 0.234 Lb of Limestone/Lb Coal and 6460.2 Lb Coal/hr

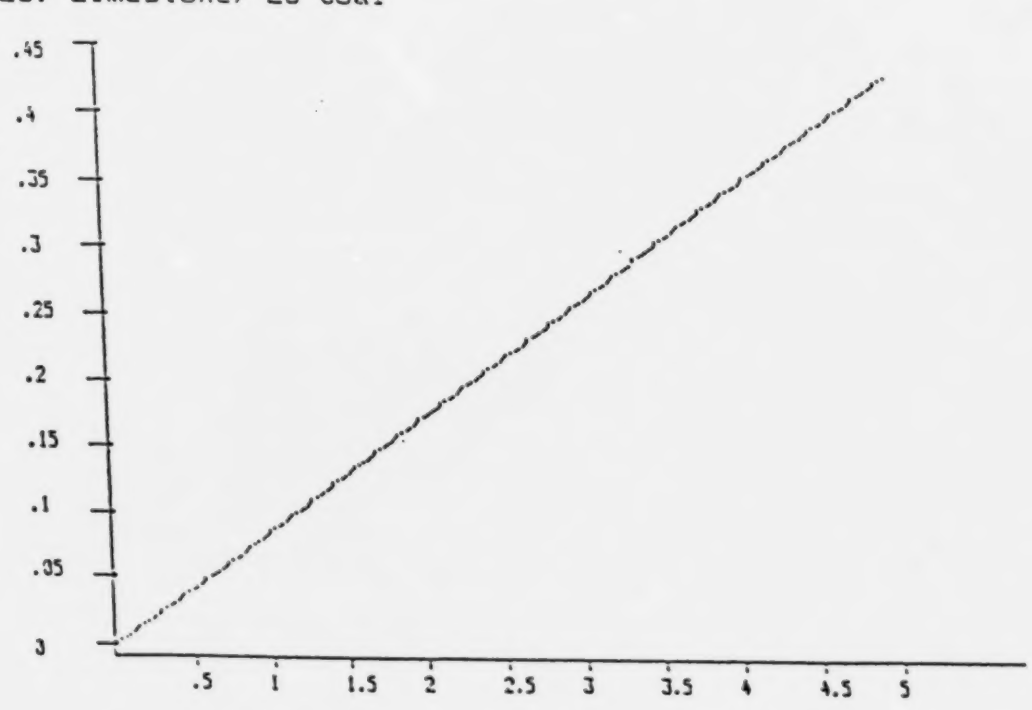
NOVA SCOTIA COAL

Lb. of limestone per Lb of Coal against % Sulphur by weight in Coal

Assumed Base Coal Analysis by weight

Carbon	.6768
Hydrogen	.0432
Sulphur	.027
Nitrogen	.0126
Ash	.09
Oxygen	.0504
Moisture	.1

- 90 % CaCO3 Limestone by wt. and a Ca/S Ratio of 2.5
- 12885.6 BTU/lb Coal (HHV Wet Basis).
- a Boiler Efficiency of 82% and an Output of 20 MW



Base Case is 2.7% (3% dry) Sulphur Coal giving 0.234 Lb of Limestone/Lb Coal and 6460.2 Lb Coal/hr

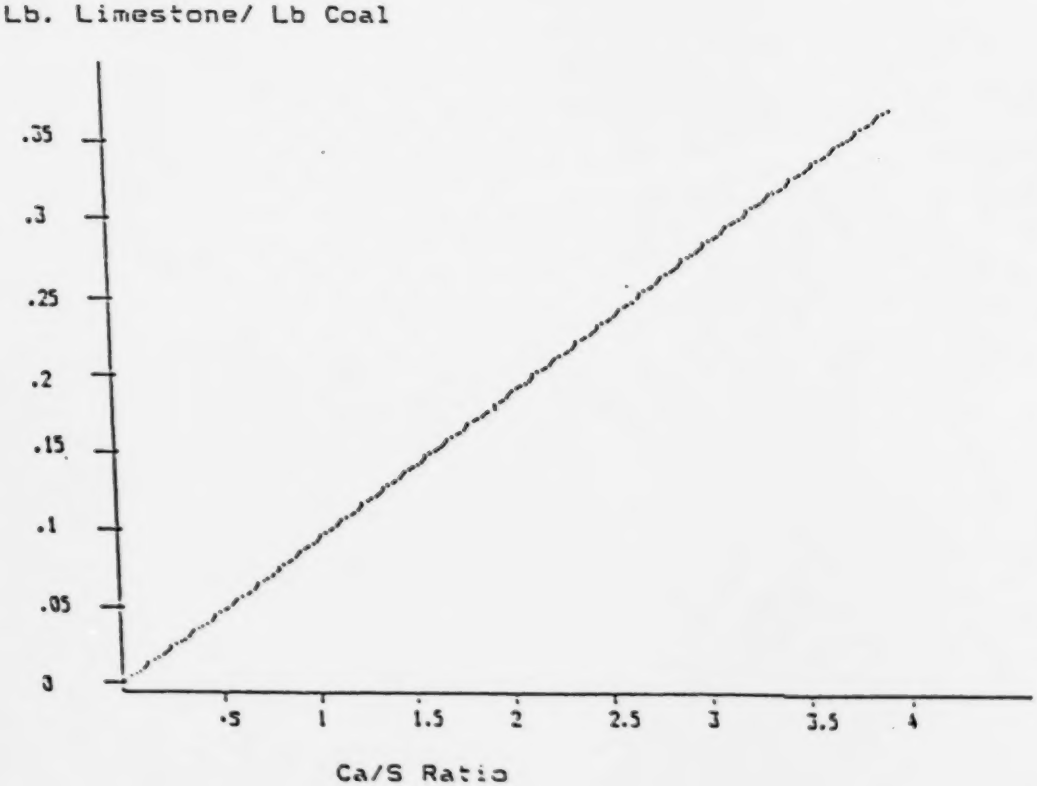
NOVA SCOTIA COAL

Lb. of limestone per Lb of Coal against Ca/S Ratio

Assumed Coal Analysis by weight

Carbon	.6768
Hydrogen	.0432
Sulphur	.027
Nitrogen	.0126
Ash	.09
Oxygen	.0504
Moisture	.1

- 2.7% Sulphur Coal on a wet basis (3% dry) and 90% CaCO3 Limestone
- 12885.6 BTU/lb Coal (HHV Wet Basis)
- a Boiler Efficiency of 82% and an Output of 20 MW



Base Case is 2.5 Ca/S Ratio giving 0.234 Lb of Limestone per Lb Coal and 6460.2 Lb Coal/hr

KENTUCKY COAL

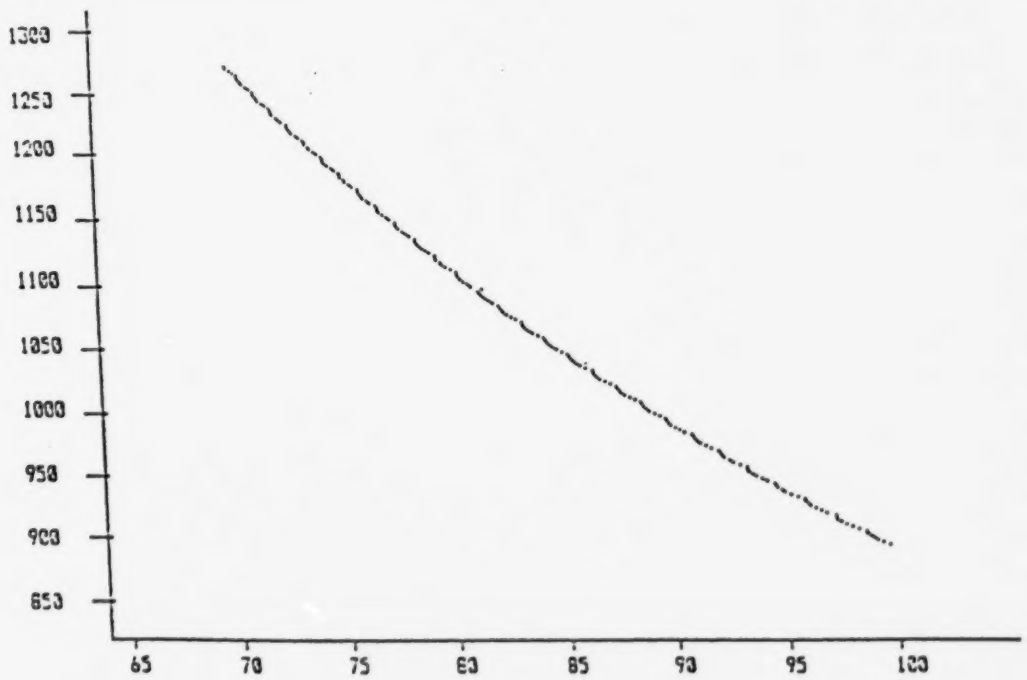
LB of limestone per Hour against % CaCO3 by weight in Limestone

Assumed Coal Analysis by weight

Carbon	.6537
Hydrogen	.045
Sulphur	.0177
Nitrogen	.013
Ash	.0798
Oxygen	.0831
Moisture	.1077

- 1.77% Sulphur Coal on a wet basis (1.9% dry) and a Ca/S Ratio of 2.5
- 11690 BTU/lb Coal (HHV Wet Basis)
- a Boiler Efficiency of 82% and an Output of 20 MW

LB Limestone/ Hour



Base Case is 90% CaCO3 Limestone and 991.3 Lb of Limestone per hr. and 7121.0 lb Coal per hour.

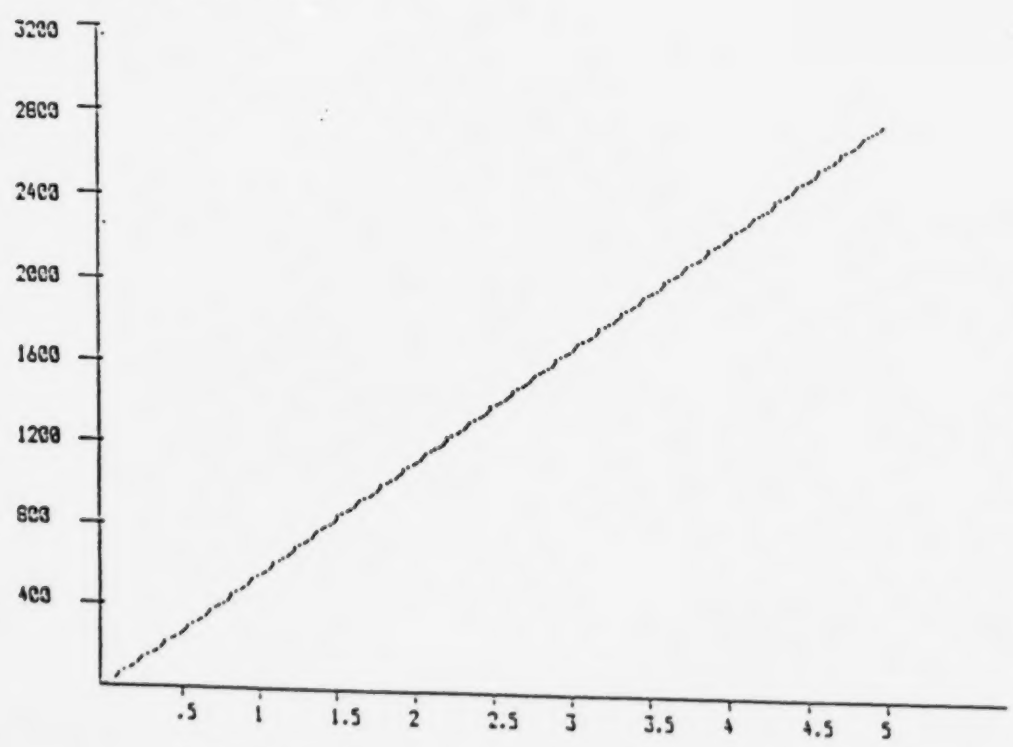
ENTUCKY COAL

Lb. of limestone per Hour against % Sulphur by weight in Coal

Assumed Base Coal Analysis by weight

Carbon	.6537
Hydrogen	.045
Sulphur	.0177
Nitrogen	.013
Ash	.0798
Oxygen	.0831
Moisture	.1077

- 90 % CaCO3 Limestone by wt. and a Ca/S Ratio of 2.5
- 11690 BTU/lb Coal (HHV Wet Basis)
- a Boiler Efficiency of 82% and an Output of 20 MW



Base Case is 1.77% (1.97 dry) Sulphur Coal giving 991.3 Lb of Limestone/ 7121.0 Lb of Coal/hr.

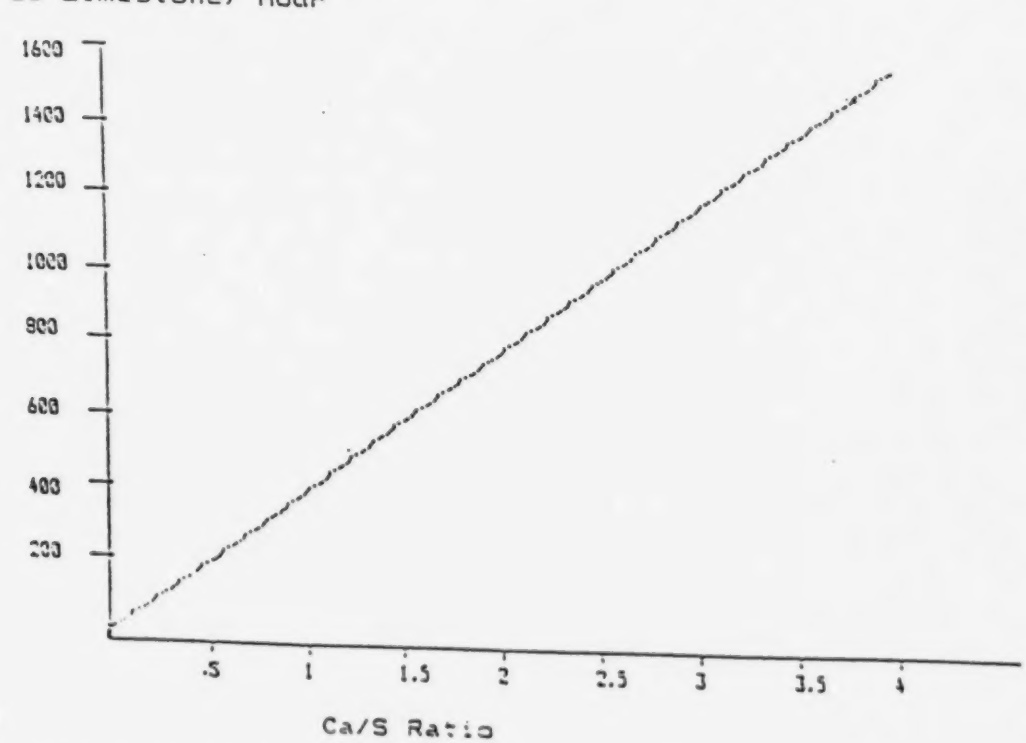
KENTUCKY COAL

Lb. of limestone per Hour against Ca/S Ratio

Assumed Coal Analysis by weight

Carbon	.6537
Hydrogen	.045
Sulphur	.0177
Nitrogen	.013
Ash	.0798
Oxygen	.0831
Moisture	.1077

- 1.77% Sulphur Coal on a wet basis (1.97 dry) and 90% CaCO3 Limestone
- 11690 BTU/lb Coal (HHV Wet Basis)
- a Boiler Efficiency of 82% and an Output of 20 MW



Base Case is 2.5 Ca/S Ratio giving 991.3 Lb of Limestone per hr. and 7121.3 Lb of Coal/hr.

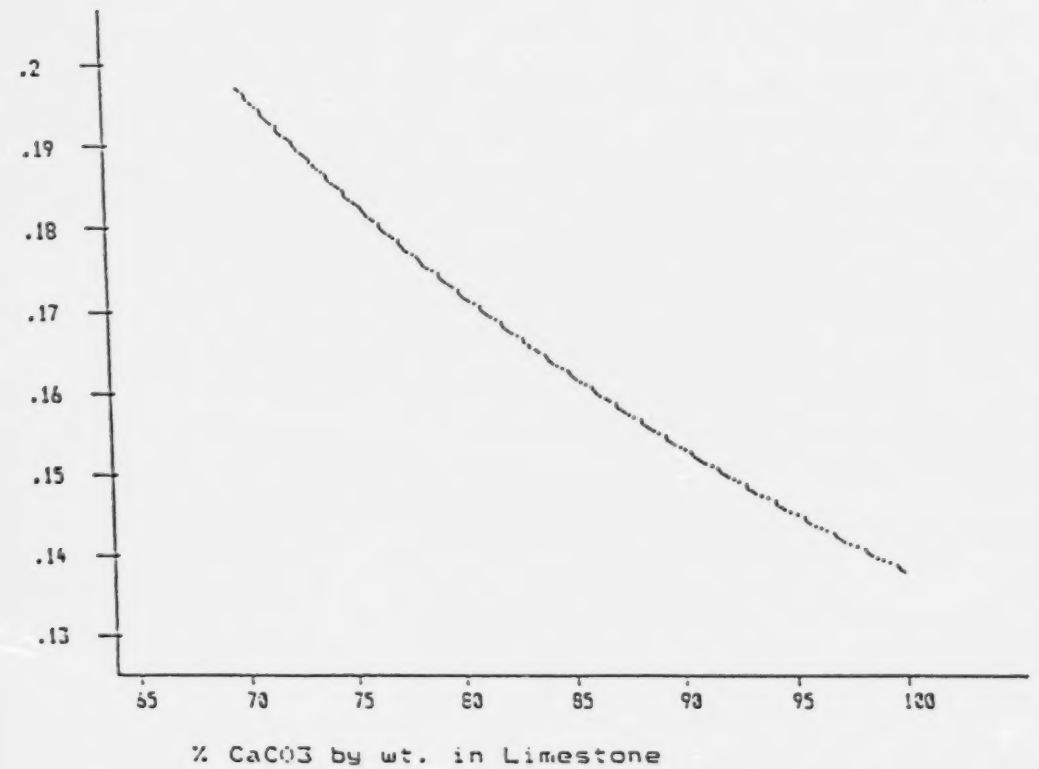
KENTUCKY COAL

LB of limestone per Lb of Coal against % CaCO3 by weight in Limestone

Assumed Coal Analysis by weight

Carbon	.6537
Hydrogen	.045
Sulphur	.0177
Nitrogen	.013
Ash	.0798
Oxygen	.0831
Moisture	.1077

- 1.77% Sulphur Coal on a wet basis (1.97 dry) and a Ca/S Ratio of 2.5
- 11690 BTU/ lb Coal (HHV Wet Basis)
- a Boiler Efficiency of 82% and an Output of 20 MW



Base Case is 90% CaCO3 Limestone and 0.15Lb of Limestone per Lb Coal and 7121.0 lb Coal per hour.

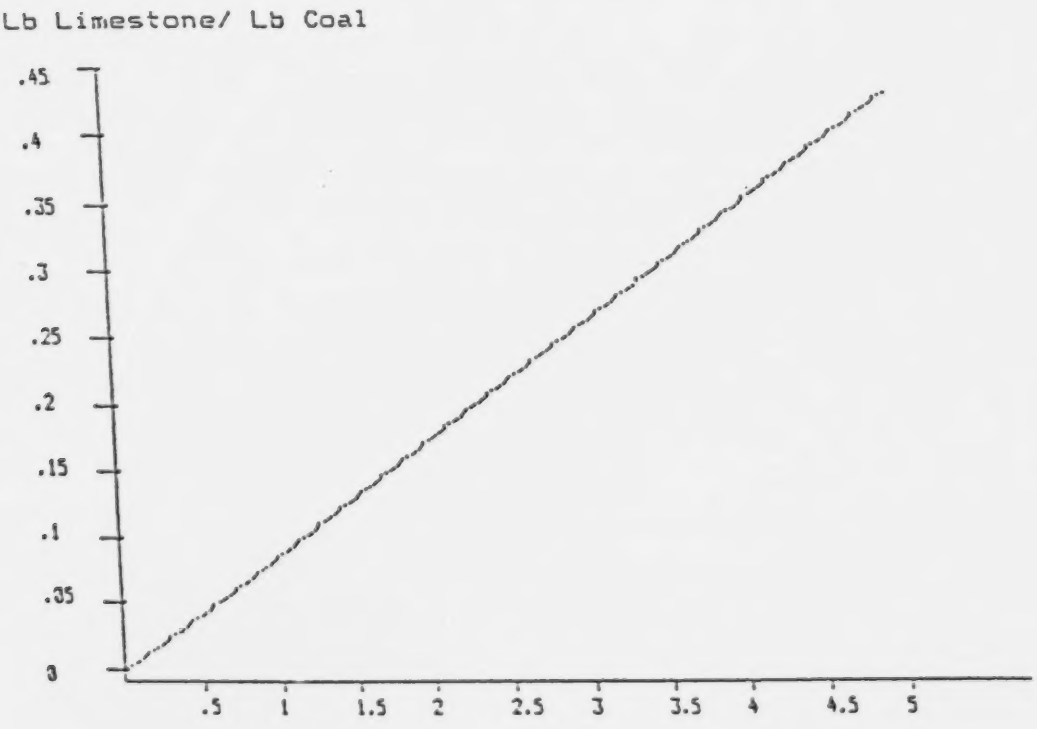
:ENTUCKY COAL

_B of limestone per Lb of Coal against % Sulphur by weight in Coal

Assumed Base Coal Analysis by weight

Carbon	.6537
Hydrogen	.045
Sulphur	.0177
Nitrogen	.013
Ash	.0798
Oxygen	.0831
Moisture	.1077

- 90 % CaCO3 Limestone by wt. and a Ca/S Ratio of 2.5
- 11690 BTU/lb Coal (HHV Wet Basis)
- a Boiler Efficiency of 82% and an Output of 20 MW



Base Case is 1.77% (1.97 dry) Sulphur Coal and 0.15Lb of Limestone per Lb Coal and 7121.0 lb Coal/hr.

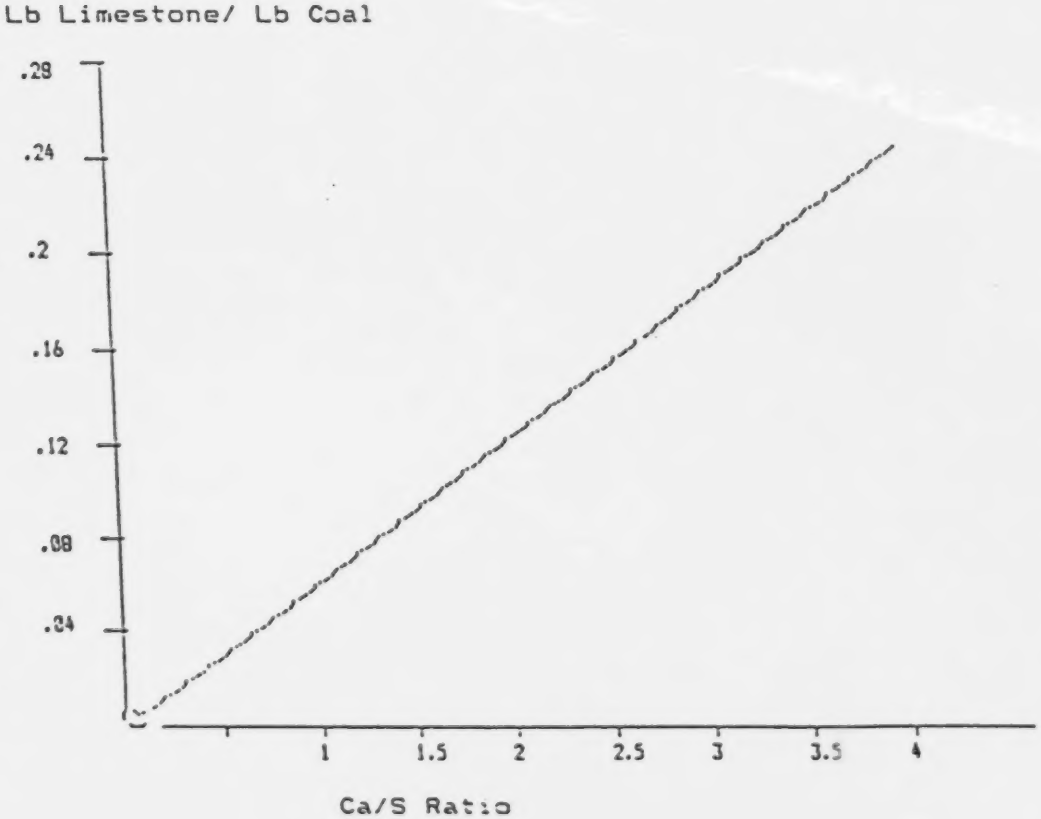
KENTUCKY COAL

"B of limestone per Lb of Coal against Ca/S Ratio"

Assumed Coal Analysis by weight

Carbon	.6537
Hydrogen	.045
Sulphur	.0177
Nitrogen	.013
Ash	.0798
Oxygen	.0831
Moisture	.1077

- 1.77% Sulphur Coal on a wet basis (1.97 dry) and 90% CaCO3 Limestone
- 11690 BTU/lb Coal (HHV Wet Basis)
- a Boiler Efficiency of 82% and an Output of 20 MW



Base Case is 2.5 Ca/S Ratio and 0.15Lb of Limestone per Lb Coal and 7121.0 lb Coal/hr.

Ca/S Ratio Versus Limestone Requirement

Ca/S MOLE RATIO	% S by WT. in COAL	% CaCO3 by WT in LIMESTONE	LB or KG LIMESTONE PER LB or KG COAL
2.000	0.50	90.00	0.0347
2.000	1.00	90.00	0.0694
2.000	1.50	90.00	0.1040
2.000	2.00	90.00	0.1387
2.000	2.50	90.00	0.1734
2.000	3.00	90.00	0.2081
2.000	3.50	90.00	0.2427
2.000	4.00	90.00	0.2774
2.000	4.50	90.00	0.3121

Ca/S MOLE RATIO	% S by WT. in COAL	% CaCO3 by WT in LIMESTONE	LB or KG LIMESTONE PER LB or KG COAL
2.500	0.50	90.00	0.0433
2.500	1.00	90.00	0.0867
2.500	1.50	90.00	0.1300
2.500	2.00	90.00	0.1734
2.500	2.50	90.00	0.2167
2.500	3.00	90.00	0.2601
2.500	3.50	90.00	0.3034
2.500	4.00	90.00	0.3468
2.500	4.50	90.00	0.3901

MOLE RATIO	by WT. in COAL	by WT in LIMESTONE	LIMESTONE PER LB or KG COAL
3.000	0.50	90.00	0.0520
3.000	1.00	90.00	0.1040
3.000	1.50	90.00	0.1561
3.000	2.00	90.00	0.2081
3.000	2.50	90.00	0.2601
3.000	3.00	90.00	0.3121
3.000	3.50	90.00	0.3641
3.000	4.00	90.00	0.4161
3.000	4.50	90.00	0.4682

APPENDIX 4

HAVELOCK LIME WORKS LTD.
P.O.Box 59, Havelock, N.B. E0A 1W0
PHONE: 534-2311 TELEX: 014-2651

May 28, 1982

G. A. Robb
1855 Beattie Ave
Ottawa, Ontario
K1H 5R7

Dear Mr. Robb,

We are pleased to enclose a sieve analysis on our 200 mesh material which is marketed as lime dust.

We enclose our brochure explaining some of our other limestone products.

Yours truly,

J. L. Murray
General Manager

JLM:kb
enc.

SIEVE ANALYSIS LIME DUST

May 28, 1982

Size	Wt %
+100 mesh	2.7
-100+200 mesh	4.7
-200+230 mesh	3.1
-230+270 mesh	7.3
-270+325 mesh	3.2
- 325 mesh	79.1
	100.1

30 Tonnes/truck

DSS File No. 15SQ.23440-3-9153
Contract Serial No. OSQ83-00128
Revised Page 4 of 4

APPENDIX "A"

SCHEDULE "B"

Performance Test Matrix for C.F.B. Gagetown
Low SO_x and NO_x Retrofit Burner

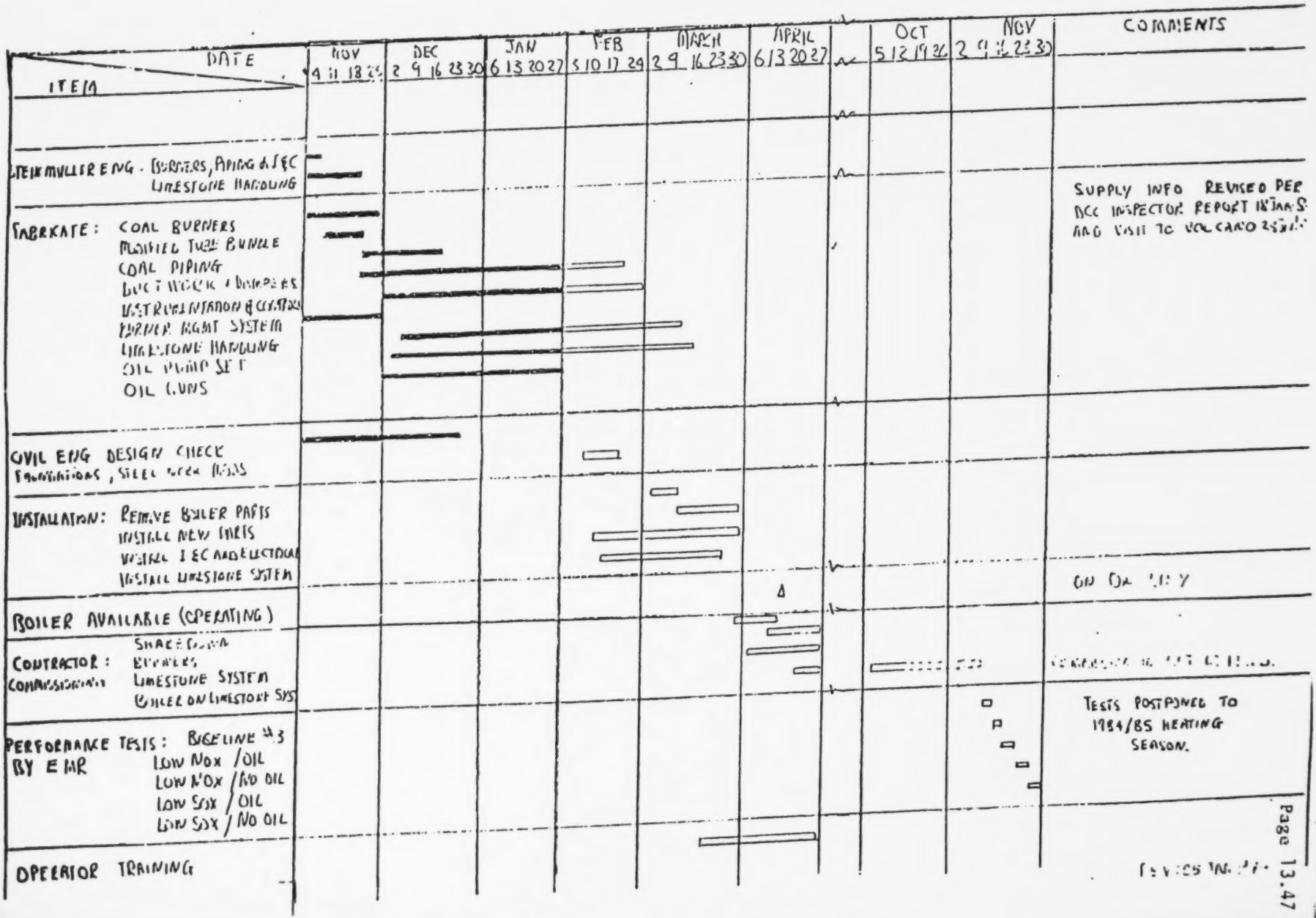
December 1984

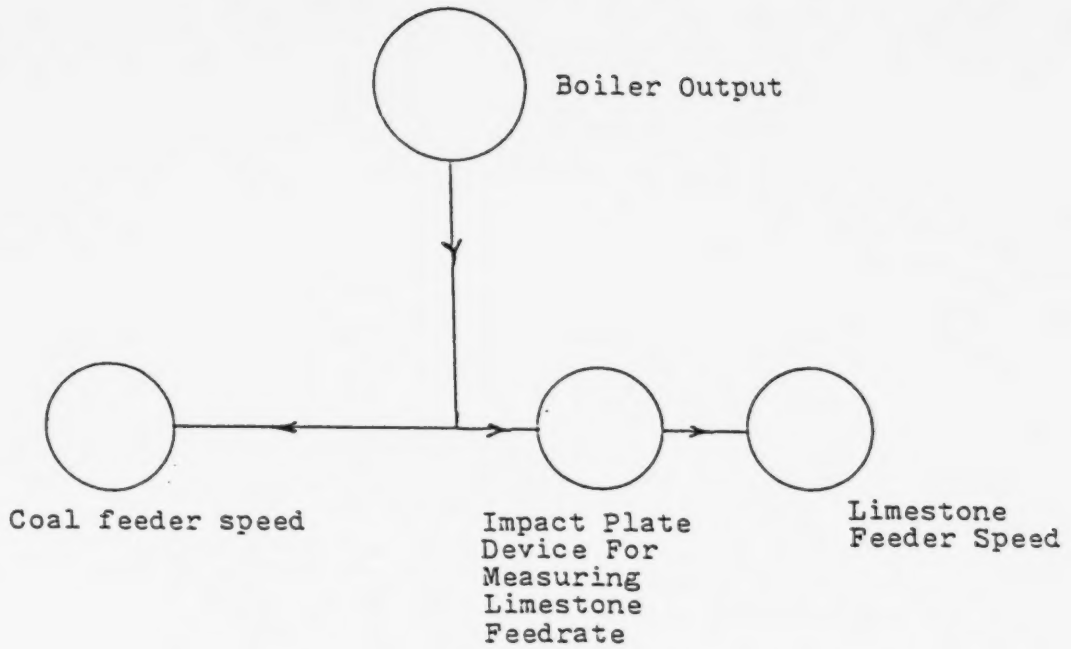
CONDITIONS	LOAD	
	100%	50%
No Additive (1)	2 Dec. 1984	2 Dec. 1984
Additive #1 (2)	3 Dec. 1984	4 Dec. 1984
Additive #2 (3)	6 Dec. 1984	7 Dec. 1984

NOTES: (1) In each case, coal will be fired with no oil support fuel.

(2) Additive #1 will be Havelock Limestone.

(3) A second additive may be tried at the option of the contractor with the concurrence of the Scientific Authority.


DATE
ITEM
NOV 4 11 18 25
DEC 2 9 16 23 30
JAN 6 13 20 27
FEB 3 10 17 24
MARCH 2 9 16 23 30
APRIL 6 13 20 27
OCT 5 12 19 26
NOV 2 9 16 23 30
COMMENTS
STEINMULLER ENG. - BURNERS, PIPING & DEC
LIMESTONE HANDLING
SUPPLY INFO REVISED PER DCC INSPECTOR REPORT IN JAN 85 AND VISIT TO VOLCANO 2/5/85
FABRICATE: COAL BURNERS
MODIFIED TUBE BUNDLE
COAL PIPING
DUCT WORK & DAMPERS
INSTRUMENTATION & CONTROLS
BURNER MGMT SYSTEM
LIMESTONE HANDLING
OIL PUMP SET
OIL GUNS
CIVIL ENG DESIGN CHECK
FOUNDATIONS, STEEL WORK LOADS
INSTALLATION: REMOVE BOILER PARTS
INSTALL NEW PARTS
WELDING I&C AND ELECTRICAL
INSTALL LIMESTONE SYSTEM
ON DAILY
BOILER AVAILABLE (OPERATING)
CONTRACTOR COMMISSIONING: SHAKEDOWN
BURNERS
LIMESTONE SYSTEM
BOILER ON LIMESTONE SYS
TESTS POSTPONED TO 1984/85 HEATING SEASON.
PERFORMANCE TESTS BY EMR: BASELINE #3
LOW NOx / OIL
LOW NOx / NO OIL
LOW SOx / OIL
LOW SOx / NO OIL
OPERATOR TRAINING



Boiler input = Boiler Output/ Boiler Efficiency

Limestone Feedrate Adjusted by Signal to Coal Feeder Speed
To Maintain Ca/S ratio

SUMMARY SHEET

ASME TEST FORM FOR ABBREVIATED EFFICIENCY TEST

PTC 4.1-2

OWNER OF PLANT	TEST NO.	BOILER NO.	DATE
TEST CONDUCTED BY	LOCATION		
BOILER MAKE & TYPE	OBJECTIVE OF TEST		DURATION
STOKER TYPE & SIZE		RATED CAPACITY	
PULVERIZER, TYPE & SIZE		BURNER, TYPE & SIZE	
FUEL USED	MINE / COUNTY / STATE		SIZE AS FIRED

PRESSURES & TEMPERATURES

1	STEAM PRESSURE IN BOILER DRUM	psia	
2	STEAM PRESSURE AT S. H. OUTLET	psia	
3	STEAM PRESSURE AT R. H. INLET	psia	
4	STEAM PRESSURE AT R. H. OUTLET	psia	
5	STEAM TEMPERATURE AT S. H. OUTLET	F	
6	STEAM TEMPERATURE AT R H INLET	F	
7	STEAM TEMPERATURE AT R.H. OUTLET	F	
8	WATER TEMP. ENTERING (ECON.) (BOILER)	F	
9	STEAM QUALITY % MOISTURE OR P. P. M.		
10	AIR TEMP. AROUND BOILER (AMBIENT)	F	
11	TEMP AIR FOR COMBUSTION (This is Reference Temperature) †	F	
12	TEMPERATURE OF FUEL	F	
13	GAS TEMP. LEAVING (Boiler) (Econ.) (Air Htr.)	F	
14	GAS TEMP. ENTERING AH (If conditions to be corrected to guarantee)	F	

UNIT QUANTITIES

15	ENTHALPY OF SAT. LIQUID (TOTAL HEAT)	Btu/lb	
16	ENTHALPY OF (SATURATED) (SUPERHEATED) STM.	Btu/lb	
17	ENTHALPY OF SAT. FEED TO (BOILER) (ECON.)	Btu/lb	
18	ENTHALPY OF REHEATED STEAM R.H. INLET	Btu/lb	
19	ENTHALPY OF REHEATED STEAM R. H. OUTLET	Btu/lb	
20	HEAT ABS/LB OF STEAM (ITEM 16 – ITEM 17)	Btu/lb	
21	HEAT ABS/LB R.H. STEAM (ITEM 19 – ITEM 18)	Btu/lb	
22	DRY REFUSE (ASH PIT + FLY ASH) PER LB AS FIRED FUEL	lb/lb	
23	Btu PER LB IN REFUSE (WEIGHTED AVERAGE)	Btu/lb	
24	CARBON BURNED PER LB AS FIRED FUEL	lb/lb	
25	DRY GAS PER LB AS FIRED FUEL BURNED	lb/lb	

HOURLY QUANTITIES

26	ACTUAL WATER EVAPORATED	lb/hr	
27	REHEAT STEAM FLOW	lb/hr	
28	RATE OF FUEL FIRING (AS FIRED wt)	lb/hr	
29	TOTAL HEAT INPUT $\frac{(\text{Item 28} \times \text{Item 41})}{1000}$	kB/hr	
30	HEAT OUTPUT IN BLOWDOWN WATER	kB/hr	
31	TOTAL HEAT OUTPUT* $\frac{\text{Item 26}(\text{Item 20}) + \text{Item 27}(\text{Item 21}) + \text{Item 30}}{1000}$	kB/hr	

FLUE GAS ANAL. (BOILER) (ECON) (AIR HTR) OUTLET

32	CO_2	% VOL	
33	O_2	% VOL	
34	CO	% VOL	
35	N_2 (BY DIFFERENCE)	% VOL	
36	EXCESS AIR	%	

FUEL DATA

	COAL AS FIRED PROX. ANALYSIS	% wt		OIL	
37	MOISTURE		51	FLASH POINT F*	
38	VOL MATTER		52	Sp. Gravity Deg. API*	
39	FIXED CARBON		53	VISCOSITY AT SSU* BURNER SSF	
40	ASH		44	TOTAL HYDROGEN % wt	
	TOTAL		41	Btu per lb	
41	Btu per lb AS FIRED				
42	ASH SOFT TEMP. ASTM METHOD			GAS	% VOL
	COAL OR OIL AS FIRED ULTIMATE ANALYSIS		54	CO	
43	CARBON		55	CH_4 METHANE	
44	HYDROGEN		56	C_2H_2 ACETYLENE	
45	OXYGEN		57	C_2H_4 ETHYLENE	
46	NITROGEN		58	C_2H_6 ETHANE	
47	SULPHUR		59	H_2S	
40	ASH		60	CO_2	
37	MOISTURE		61	H_2 HYDROGEN	
	TOTAL			TOTAL	
	COAL PULVERIZATION			TOTAL HYDROGEN % wt	
48	GRINDABILITY INDEX*		62	DENSITY 68 F ATM. PRESS.	
49	FINENESS % THRU 50 M*		63	Btu PER CU FT	
50	FINENESS % THRU 200 M*		41	Btu PER LB	
64	INPUT-OUTPUT EFFICIENCY OF UNIT %		$\frac{\text{ITEM 31} \times 100}{\text{ITEM 29}}$		

	HEAT LOSS EFFICIENCY	Btu/lb A. F. FUEL	% of A. F. FUEL
65	HEAT LOSS DUE TO DRY GAS		
66	HEAT LOSS DUE TO MOISTURE IN FUEL		
67	HEAT LOSS DUE TO H_2O FROM COMB. OF H_2		
68	HEAT LOSS DUE TO COMBUST. IN REFUSE		
69	HEAT LOSS DUE TO RADIATION		
70	UNMEASURED LOSSES		
71	TOTAL		
72	EFFICIENCY = (100 – Item 71)		

* Not Required for Efficiency Testing

† For Point of Measurement See Par. 7.2.3.1-PTC 4.1-1934

ASME TEST FORM
CALCULATION SHEET FOR ABBREVIATED EFFICIENCY TEST

Revised September, 1965

OWNER OF PLANT ..... TEST NO. ..... BOILER NO. ..... DATE .....

HEAT OUTPUT IN BOILER BLOW-DOWN WATER = LB OF WATER BLOW-DOWN PER HR $\times \left[\frac{\text{ITEM 15} - \text{ITEM 17}}{1000}\right]$ = ... kB/hr

If impractical to weigh refuse, this item can be estimated as follows

DRY REFUSE PER LB OF AS FIRED FUEL = $\frac{\%\text{ ASH IN AS FIRED COAL}}{100 - \%\text{ COMB. IN REFUSE SAMPLE}}$

CARBON BURNED PER LB AS FIRED FUEL = $\frac{\text{ITEM 43}}{100} - \left[\frac{\text{ITEM 22} \times \text{ITEM 23}}{14{,}500}\right]$ = ...

NOTE: IF FLUE DUST & ASH PIT REFUSE DIFFER MATERIALLY IN COMBUSTIBLE CONTENT, THEY SHOULD BE ESTIMATED SEPARATELY. SEE SECTION 7, COMPUTATIONS.

DRY GAS PER LB AS FIRED FUEL BURNED = $\frac{11CO_2 + 8O_2 + 7(N_2 + CO)}{3(CO_2 + CO)} \times$ (LB CARBON BURNED PER LB AS FIRED FUEL + $\frac{3}{8}$ S)

$$= \frac{11 \times \text{ITEM 32} + 8 \times \text{ITEM 33} + 7\left(\text{ITEM 35} + \text{ITEM 34}\right)}{3 \times \left(\text{ITEM 32} + \text{ITEM 34}\right)} \times \left[\text{ITEM 24} + \frac{\text{ITEM 47}}{267}\right] = ...$$

EXCESS AIR † $= 100 \times \frac{O_2 - \frac{CO}{2}}{.2682N_2 - (O_2 - \frac{CO}{2})} = 100 \times \frac{\text{ITEM 33} - \frac{\text{ITEM 34}}{2}}{.2682\,(\text{ITEM 35}) - (\text{ITEM 33} - \frac{\text{ITEM 34}}{2})}$ = ...

HEAT LOSS EFFICIENCY	Btu/lb AS FIRED FUEL	$\frac{\text{LOSS}}{\text{HHV}} \times \frac{}{100}$ =	LOSS %
HEAT LOSS DUE TO DRY GAS = LB DRY GAS PER LB AS FIRED FUEL $\times C_p \times (t_{\text{Flue Gas}} - t_{\text{air}}) =$ ITEM 25 $\times$ 0.24 (ITEM 13) − (ITEM 11) = ...	.....	$\frac{65}{41} \times 100 =$	.....
HEAT LOSS DUE TO MOISTURE IN FUEL = LB H_2O PER LB AS FIRED FUEL $\times$ [(ENTHALPY OF VAPOR AT 1 PSIA & T GAS LVG) − (ENTHALPY OF LIQUID AT T AIR)] = $\frac{\text{ITEM 37}}{100} \times$ [(ENTHALPY OF VAPOR AT 1 PSIA & T ITEM 13) − (ENTHALPY OF LIQUID AT T ITEM 11)] = ...	.....	$\frac{66}{41} \times 100 =$	.....
HEAT LOSS DUE TO H_2O FROM COMB. OF H_2 = $9H_2 \times$ [(ENTHALPY OF VAPOR AT 1 PSIA & T GAS LVG) − (ENTHALPY OF LIQUID AT T AIR)] $= 9 \times \frac{\text{ITEM 44}}{100} \times$ [(ENTHALPY OF VAPOR AT 1 PSIA & T ITEM 13) − (ENTHALPY OF LIQUID AT T ITEM 11)] = ...	.....	$\frac{67}{41} \times 100 =$	.....
HEAT LOSS DUE TO COMBUSTIBLE IN REFUSE = ITEM 22 $\times$ ITEM 23 = ...	.....	$\frac{68}{41} \times 100 =$	.....
HEAT LOSS DUE TO RADIATION* = $\frac{\text{TOTAL BTU RADIATION LOSS PER HR}}{\text{LB AS FIRED FUEL} - \text{ITEM 28}}$	.....	$\frac{69}{41} \times 100 =$	.....
UNMEASURED LOSSES **	.....	$\frac{70}{41} \times 100 =$	.....
TOTAL	.....	.....	.....
EFFICIENCY = (100 − ITEM 71)	.....	.....	.....

† For determination of excess air see Appendix 9.2 – PTC 4.1-1964

* To be measured, use ASMA Standard Radiation Loss Chart, Fig. 8, PTC 4.1-1964

** Any other losses listed in PTC 4.1 but not tabulated above may by provided for by assigning a mutually agreeable value for Item 70.

TEST NUMBER	UNIT NUMBER	DATE	TIME	PERCENTAGE OF FULL LOAD	LIMESTONE FEED
1	2	Nov. 23	11:30-14:15	100	No
2	2	Nov. 23	21:00-24:00	100	Yes
3	1	Nov. 27	12:30-14:15	100	No
4	2	Nov. 24	15:30-20:30	50	No
5	2	Nov. 25	11:00-16:00	50	Yes
6	2	Nov. 26	12:00-15:30	100	No
7	2	Nov. 26	15:30-17:00	100	Yes
7a	2	Nov. 26	17:00-17:45	100	Yes
7b	2	Nov. 26	17:45-18:15	100	Yes
8	1	Nov. 27	15.00-16.30	50	No
9	2	Nov. 28	11:00-12:00	100	Yes
9a	2	Nov. 28	12:00-14:15	50	Yes

TEST No.	UNIT No.	DATE	% OF FULL LOAD	LIMESTONE FEEDRATE (kg/hr)	A.H. GAS IN TEMP (C)	% C IN FLY ASH	EFFICIENCY Over-All •	EFFICIENCY Coal Only	Ca/S Ratio	SO2 (ppm)	NOx (ppm)
1	2	23	100	0.0	378.0	42.5	80.5	80.4	0	2450	245
2	2	23	100	749.3	389.5	N.C.	79.9		3.02	1136	254
8	1	27	100	0.0	354.0	19.2	84.3		0	2087	567
9	2	28	100	541.0	372.8	N.C.	81.4		2.38	1169	212

N.C.: Not Comparable (The extra ash due to limestone addition would make the percentage carbon lower.)

Note: The calculation for test 11 was performed using the coal and ash analyses of test 2. Both tests used the same test coal and limestone.

• The overall efficiency was calculated by the loss method using a combined analysis of coal, oil and limestone. The "coal only" efficiency calculation u coal feedrate determined in the overall or combined fuel efficiency.

As indicated above 42.5% of the ash collected in the cyclone, when operating without limestone, was found to be unburned carbon. This is above the 7% required by the contract and the 19.2% collected in the unit 1 cyclone.

TEST 1: 11/23, Average of 13:30-14:15, 100% Load, Test Coal, No Lime.

•% Ash to Cyclone & Carryover	75	85	95	85	85	85	85
% C in Cyclone Ash	42.48	42.48	42.48	42.48	42.48	42.48	42.48
AH Outlet Temp. (C)	248.6	248.6	248.6	248.6	248.6	248.6	248.6
% O2 by Vol	4.51	4.51	4.51	4.51	4.51	4.51	4.51
•Blr Output (MW)	17.9	17.9	17.9	15.9	19.9	17.9	17.9
*Oil Flowrate (L/hr)	91.8	91.8	91.8	91.8	91.8	41.8	141.8
Oil (% of Total Fuel Input)	4.5	4.46	4.43	5.02	4.01	2.03	6.9
Limestone Feedrate (kg/hr)	0	0	0	0	0	0	0
Coal Feedrate (kg/hr)	2385	2403	2424	2122	2684	2465	2341
Unburned C in Ash Loss (%)	3.64	4.29	5.03	4.27	4.31	4.4	4.18
H2 & H2O Loss (%)	4.39	4.39	4.39	4.41	4.37	4.31	4.47
Dry Gas Loss (%)	9.43	9.37	9.31	9.37	9.37	9.38	9.37
COMBINED FUEL EFFICIENCY (%)	81.7	81.2	80.5	81.2	81.1	81.1	81.2
Assumed % Sulphur Absorption	0	0	0	0	0	0	0
% CaCO3 in limestone	95.3	95.3	95.3	95.3	95.3	95.3	95.3
Ca/S RATIO	0	0	0	0	0	0	0

TEST 1: 11/23, Average of 13:30-14:15, Test Coal Only, No Lime., No Oil

•% Ash to Cyclone & Carryover	75	85	95	85	85	85	85
% C in Cyclone Ash	42.48	42.48	42.48	42.48	42.48	42.48	42.48
AH Outlet Temp. (C)	248.6	248.6	248.6	248.6	248.6	248.6	248.6
% O2 by Vol	4.51	4.51	4.51	4.51	4.51	4.51	4.51
•Blr Output (MW)	17.090	17.088	17.088	15.090	19.086	17.529	16.647
*Oil Flowrate (L/hr)	0	0	0	0	0	0	0
Oil (% of Total Fuel Input)	0	0	0	0	0	0	0
Limestone Feedrate (kg/hr)	0	0	0	0	0	0	0
Coal Feedrate (kg/hr)	2385	2403	2424	2122	2684	2465	2341
Unburned C in Ash Loss (%)	3.81	4.49	5.26	4.49	4.49	4.49	4.49
H2 & H2O Loss (%)	4.24	4.24	4.24	4.24	4.24	4.24	4.24
Dry Gas Loss (%)	9.44	9.38	9.31	9.38	9.38	9.38	9.38
COAL FUEL EFFICIENCY (%)	81.7	81.1	80.4	81.1	81.1	81.1	81.1
Assumed % Sulphur Absorption	0	0	0	0	0	0	0
% CaCO3 in limestone	95.3	95.3	95.3	95.3	95.3	95.3	95.3
Ca/S RATIO	0	0	0	0	0	0	0

The above calculation estimates the efficiency and MW output due to coal only. The coal feedrate was taken from the combined fuel calculation.

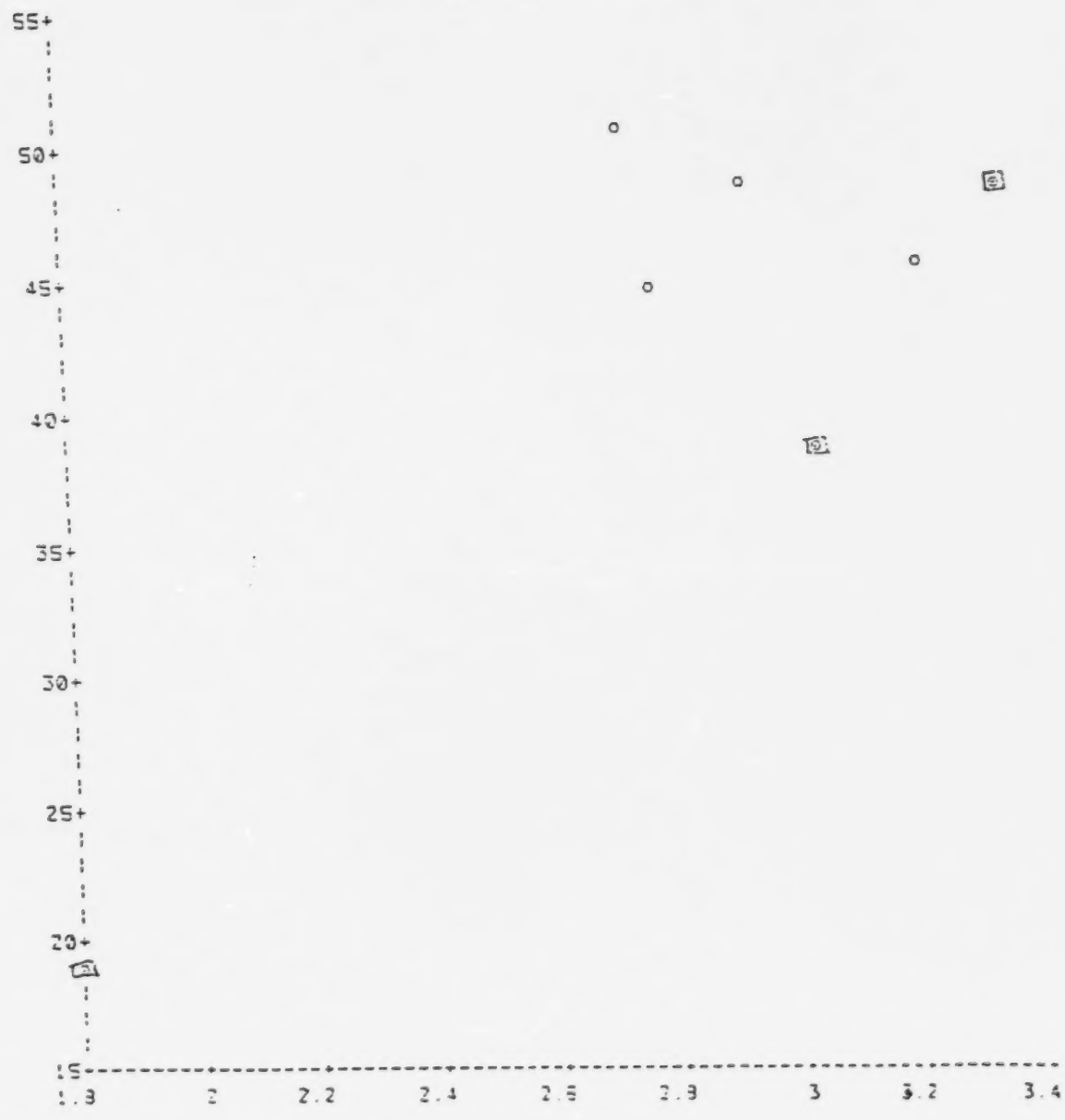
• Quantities varied to show sensitivity to errors in measurement or assumption resulting from the limestone (organic carbon).

Performance Tests with Limestone Added

	TEST	2	5	7	7a	7b	8	9
	DATE	Nov23	Nov25	Nov26	Nov26	Nov26	Nov28	Nov28
	TIME Start	20.45	11	15.3	.7	17.45	11	12
	End	-24	-16	-17	-17.45	-18.15	-12	-14.15
	COAL	Test	Test	Base	Base	Base	Test	Test
I								
	Ca/S MOLE RATIO	3.21	2.74	3.05	1.8	3.36	2.78	2.93
	COMBINED FUEL EFFICIENCY%	80.8	81	79.6	82.1	79.4	82.3	81.3
*	SO2 Absorption %	45.6	51	39.5	19.5	49.3	45.3	49.4
	PPM of SO2	1136	1133	653	853	570	1069	1047
	Calcium efficiency	.14189	.18594	.12945	.10831	.14673	.16299	.16875
I								
	%Ash to Cyclone+Carryover	85	85	85	85	85	85	85
+	% Carbon in Bottom Ash	.88	8.47	2.66	2.26	2.26	.24	.27
+	% CARBON IN CYCLONE ASH	10.6	19.88	32.55	27	27	13	13.93
	Unburned C in Ash Loss %	3.34	6.78	6.77	3.75	5.92	3.32	3.95
I								
	AH Outlet Temp. (C)	262.8	200.6	243.6	255.6	254.75	245.3	255.4
	% O2 by Vol	5.3	5.4	5	4.9	5.63	5.175	4.85
	Blr Output (MW)	17.5	10.7	16.9	17.1	16.57	16.4	16.3
	H2 & H2O Loss (%)	4.76	4.19	4.22	4.17	4.3	4.41	4.76
	Dry Gas Loss (%)	10.29	7.26	8.66	9.2	9.61	9.13	9.16
I								
	Oil Flowrate (L/hr)	94.5	44.1	94.5	94.5	93.3	90	90
	Oil (% Total Energy Input)	4.71	3.59	4.78	4.87	4.81	4.86	4.84
	Limestone Feedrate (kg/hr)	749.3	373.5	345.7	193	383.6	541	617.7
	KJ/kg Limestone	-591.3	-388.0	-661.9	-757.9	-578.3	-503.5	-477.1
	% CaCO3 in limestone	93.44	93.27	95.37	94.96	94.96	95.2	95.31
	Coal Feedrate (kg/hr)	2363	1492	2255	2181	2191	2147	2204
	KJ/kg Coal	31448.	30748.	32294.	32726.	32660	31778.	31159.
I								
	COAL ANALYSIS Carbon	71.5	70.12	74.16	74.38	75.12	70.31	69.01
	Hydrogen	5.32	4.76	4.89	4.92	5.09	4.97	5.1
	Nitrogen	1.22	1.44	1.37	1.59	1.45	1.4	1.42
	Oxygen	8.75	10.48	10.46	10.25	9.33	13.35	11.59
	Sulphur	2.93	2.71	1.51	1.47	1.56	2.74	2.9
	Ash	7.01	8	5.37	5.77	5.79	5.99	5.47
	Moisture	2.2	2.48	2.25	1.61	1.61	2.34	4.41

* Based on reduction in SO2 emissions, as measured by Environment Canada, from a comparable test with no limestone addition. Emissions with no limestone are adjusted by the ratio- % sulphur with/without limestone. This ensures a similar % coal sulphur the for SO2 absorption calculation.

+ Includes only the carbon due to the coal or oil and not the carbon resulting from the limestone (organic carbon).


55+
50+
45+
40+
35+
30+
25+
20+
15
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
SO2 Absorption % Against Ca/S Ratio
Low Sulphur (Base) Coal
Test Coal

MEASURED VALUES AND FLUE GAS ANALYSIS
CFB GAGETOWN

READING NO.		1	2	3	4	5	6	7	8	9
DATE 1984		29.10	30.10	30.10	30.12	2.11	2.11	2.11	3.11	3.11
TIME		17:30	13:00	14:30	16:00	11:30	17:00	18:10	11:00	14:00
PANEL IND.		COAL BR.1 + Oil	COAL BR.1 + Oil	COAL BR.1	COAL BR.1	OIL BR.1	OIL BR.1	OIL BR.2	OIL BR.2	OIL BR. 1 + 2
MW FLOW	0-25 MW	7,7	9,5	9,8	9,5	8,5	5,1	8,5	4.9	9,9
WATER FLOW	0-100%	38	42	43	44	38	34	37	33	42
AIR FLOW	0-100%	-	-	-	-	-	-	-	-	-
GAS INLET HEATER	0-400°C	335	354	323	343	295	267	305	283	351
GAS OUTLET HEATER	0-400°C	203	226	202	212	176	162	182	169	217
AIR INLET HEATER	0-400°C	-	200	162	188	167	163	172	167	194
AIR OUTLET HEATER	0-400°C	-	200	182	188	167	163	172	167	194
WATER INLET	0-200°C	150	148	150	152	150	145	147	143	150
WATER OUTLET	0-200°C	184	183	186	186	186	169	183	166	186
WATER PRESSURE	0-2000kPa	1110	1120	1120	1090	1170	990	1090	1070	1120
O_2	0-10	5	-	-	-	-3,8	5,8	3,6	6,4	3,7
DRAFT FURNACE	-100/+100Pa	-40	-50	-50	-60	-35	-35	-35	-35	-35
LOAD FD FAN	0-100 A	-	-	-	-	20	18	20	19	22
LOAD ID FAN	0-100 A	-	-	-	-	21	20	21	20	22,5
AIR HEATER BYPASS	0-100%	0	0	0	0	0	0	0	0	0
CONTROL MEAS.										
PRESS.COMB. CHAMB.	MM WG	-4	-5	-5	-5	-5	-5	-6	-5	-6
O_2	%	6	5	6	6	-	6,5	3,7	-	-
BACHARACH	-	-	-	-	-	-	-	-	-	2-3
TEMP. BOILER HOUSE	°C	25	25	25	25	25	25	25	25	25
OUTSIDE TEMP.	°C	-	-	-	-	10	10	10	10	10

MEASURED VALUES AND FLUE GAS ANALYSIS

CFB GAGETOWN

READING NO.		1	2	3	4	5	6	7	8	9
DATE 1984		29.10	30.10	30.10	30.10	2.11	2.11	2.11	3.11	3.11
TIME		17:30	13:00	14:30	16:00	11:30	17:00	18:10	17:00	14:00
BURNER NO. 1										
PANEL IND.										
TEMP. COAL/AIR	0-200°C	80	82	71	77	-	-		-	-
DRAFT INLET MILL	-100/+25 Pa	-20	-20	-20	-20	-	-		-	-
DRAFT OUTLET MILL	0-2,5 kPa	1,1	1,2	1,2	1,5	-	-		-	-
POS. SEC. AIR	0-100%	55	80	55	55	65	40		0	47
POS. TERT. AIR	0-100%	0	0	45	45	0	0		0	0
POS. PRIM. AIR	0-100%	40	45	55	60	0	0		0	0
POS. COAL FEEDER	0-100%	40	45	55	60	0	0		0	0
POS. EXHAUSTER	0-100%	35	40	45	60	0	0		0	0
POS. OIL FLOW	0-100%	50	50	0	0	100	40		0	46
POS. LIMEST. FEEDER	0-100%	0	0	0	0	0	0		0	0
MILL LOAD	0-100A	-	-	-	-	0	0		0	0
OIL NOZZLE		SM.	SM.	SM.	SM.	LA.	LA.		-	LA.
CONTROL MEAS.										
POS. AIR SWIRL	0-130 MM	0	0	0	0	80	80		80	80
POS. CORE AIR	0-90°	20	25	10	10	90	90		90	90
PRESS. SEC. AIR	MM WG	78	145	85	80	225	30		-6	33
PRESS. TERT. AIR	MM WG	0	0	65	65	-5	-1		-6	-7
PRESS. CORE AIR	MM WG	-5	-5	-10	-10	+12	+9		-7	0
PRESS. BEFORE DAMP.	MM WG	220	207	205	203	210	240		243	216
SEC. AIR FLOW	MM WG	15	28	29	30	25	9		2	11
PRIM. AIR FLOW	MM WG	33	58	43	45	0	0		0	0
OIL FLOW	1-5 V	-	-	-	-	-	-		-	-
OIL PRESS. BEF. B	0-4000 kPa	-	-	-	-	3000	2300		-	2310
OIL PRESS. AFTER B	0-4000 kPa	-	-	-	-	1900	1100		-	1150

MEASURED VALUES AND FLUE GAS ANALYSIS

CFB GAGETOWN

READING NO.		1	2	3	4	5	6	7	8	9
DATE 1984		19.10	30.10	30.10	30.10	2.11	2.11	2.11	3.11	3.11
TIME								18:00	11:00	11:00
BURNER NO. 2										
PANEL IND.										
TEMP. COAL/AIR	0-200°C							-	-	-
DRAFT INLET MILL	-100/+25 Pa							-	-	-
DRAFT OUTLET MILL	0-2.5 kPa							-	-	-
POS. SEC. AIR	0-100%							65	50	55
POS. TERT. AIR	0-100%							0	0	0
POS. PRIM. AIR	0-100%							0	0	0
POS. COAL FEEDER	0-100%							0	0	0
POS. EXHAUSTER	0-100%							0	0	0
POS. OIL FLOW	0-100%							70	37	34
POS. LIMEST. FEEDER	0-100%							0	0	0
MILL LOAD	0-100 A							0	0	0
OIL NOZZLE								LA.	LA.	LA.
CONTROL MEAS.										
POS. AIR SWIRL	0-130 MM							80	80	80
POS. CORE AIR	0-90°							90	90	90
PRESS. SEC. AIR	MM WG							77	29	36
PRESS. TERT. AIR	MM WG							-4	-4	-6
PRESS. CORE AIR	MM WG							+2	+6	+9
PRESS. BEFORE DAMP.	MM WG							222	240	222
SEC. AIR FLOW	MM WG							16	9	11
PRIM. AIR FLOW	MM WG							0	0	0
OIL FLOW	1-5 V							-	-	-
OIL. PRESS. BEF. B	0-4000 kPa							3000	2450	2300
OIL PRESS. AFTER B	0-4000 kPa							1800	1200	1100

MEASURED VALUES AND FLUE GAS ANALYSIS

CFB GAGETOWN

READING NO.		10	11	12	13	14	15	16	17	18
DATE 1984		4.11	4.11	4.11	10.11	12.11	13.11	14.11	15.11	15.11
TIME		11:00	12:00	16:00	16:00	15:30	14:30	14:00	14:00	16:00
		OIL	OIL	OIL	COAL	COAL	OIL	COAL	OIL	COAL
PANEL IND.		BR.2	BR.2	BR.2	BR.1	BR.1	BR. 1 & 2	BR. 1 & 2	BR.1	BR.1
MW FLOW	0-25 MW	8,7	10,2	9,8	10	9	8	10,2	9,3	6
WATER FLOW	0-100%	37	40,2	41,5	42	42	40	40	40	38
AIR FLOW	0-100%	-	-	-	-	-	40	58,5	40	26
GAS INLET HEATER	0-400°C	312	332	348	348	347	341	352	335	303
GAS OUTLET HEATER	0-400°C	190	206	214	216	183	203	210	200	190
AIR INLET HEATER	0-400°C	40	40	40	40	40	40	30	30	30
AIR OUTLET HEATER	0-400°C	180	185	195	186	169	191	180	177	187
WATER INLET	0-200°C	149	148	150	148	150	150	146	142	146
WATER OUTLET	0-200°C	186	188	186	184	184	180	186	179	172
WATER PRESS.	0-2000 kPa	1100	1100	1060	1050	1070	1050	1100	1100	1090
O_2	0-10%	4,5	3,9	3,4	4,5	6,5	3,2	8	3,4	5,5
DRAFT FURNACE	-100/+100 Pa	-35	-35	-35	-40	-35	-40	-40	-35	-35
LOAD FD FAN	0-100 A	20	22	22	20	20	19	23	20	18
LOAD ID FAN	0-100 A	21	22	22	21	21	20	24	20	20
AIR HEATER BYPASS	0-100%	0	0	0	0	0	0	0	0	0
AIR PRESSURE	MM WG	-	-	-	200	200	200	200	200	200
CONTROL MEAS.										
PRESS. COMB. CHAMB.	MM WG	-5	-4	-5	-6	-5	-6	-6	-5	-4
O_2	%	-	-	-	-	7,5	-	-	-	-
BACHARACH	-	4	4	6	-	-	-	-	2	-
TEMP. BOILER HOUSE	°C	25	25	25	25	25	25	25	25	25
OUTSIDE TEMP.	°C	10	10	10	10	15	15	5	5	5
COMB. CHAMBER	°C	-	-	-	-	-	-	720	685	558
LIMEST. FLOW	%	-	-	-	63	0	0	0	0	0

MEASURED VALUES AND FLUE GAS ANALYSIS
CFB GAGETOWN

READING NO.		10	11	12	13	14	15	16	17	18
DATE 1984		4.11	4.11	4.11	10.11	12.11	13.11	14.11	15.11	15.11
TIME		11:00	12:00	16:00	16:00	15:30	14:30	14:00	14:00	16:00
PANEL IND.										
TEMP. COAL/AIR	0-200°C	-	-	-	69	84	-	80	-	86
DRAFT INLET MILL	-100/+25 Pa	-	-	-	-20	-20	-	-15	-	-20
DRAFT OUTLET MILL	0-2,5 kPa	-	-	-	1,15	1,4	-	0,8	-	0,8
POS. SEC. AIR	0-100%	0	0	0	60	60	40	70	100	60
POS. TERT. AIR	0-100%	0	0	0	50	40	0	0	0	0
POS. PRIM. AIR	0-100%	0	0	0	45	45	0	52	0	45
POS. COAL FEEDER	0-100%0	0	0	0	60	50	0	50	0	55
POS. EXHAUSTER	0-100%	0	0	0	40	55	0	22	0	25
POS. OIL FLOW	0-100%	0	0	0	0	0	94	0	98	0
POS. LIMEST. FEEDER	0-100%	0	0	0	1,31	0	0	0	0	0
MILL LOAD	0-100A	0	0	0	35	33	0	28	0	26
CONTROL MEAS.										
POS. AIR SWIRL	0-130 MM	80	80	80	0	0	0	0	80	0
POS. CORE AIR	0-90°	90	90	90	0	0	45	0	45	0
PRESS. SEC. AIR	MM WG	-7	-8	-7	82	83	28	70	118	48
PRESS. TERT. AIR	MM WG	-8	-8	-8	60	35	-4	0	-7	-3
PRESS. CORE AIR	MM WG	-11	-10	-10	-14	-10	-6	-15	+1	-15
PRESS. BEFORE DAMP.	MM WG	231	219	222	170	172	189	170	175	190
SEC. AIR FLOW	MM WG	3	2	2	29	28	10	19	32	17
PRIM. AIR FLOW	MM WG	0	0	0	37	35	2	39	2	4
OIL FLOW (1200 lbs)	0-100%	0	0	0	0	-	-	-	98	0
OIL. PRESS. BEF. B	0-4000 kPa	-	-	-	0	1370	2950	1380	3050	0
OIL PRESS. AFTER B	0-4000 kPa	-	-	-	0	100	1600	100	2000	0
UV	0-10 V	-	-	-	0	5	7	6	0	0
IR	0-10 V	-	-	-	10	10	10	10	10	10
GAS BEF. MILL	°C	-	-	-	-	-	-	175		189
POS. FEEDER	0-10	-	-	-	6,1	5,2	-	4	-	4,4

MEASURED VALUES AND FLUE GAS ANALYSIS

CFB GAGETOWN

READING NO.		10	11	12	13	14	15	16	17	18
DATE 1984		4.11	4.11	4.11	10.11	12.11	13.11	14.11	15.11	15.11
TIME		11:00	12:00	16:00	16:00	15:30	14:30	14:00	14:00	16:00
PANEL IND.										
TEMP. COAL/AIR	0-200°C	-	-	-	-	-	-	80	-	-
DRAFT INLET MILL	-100/+25 Pa	-	-	-	-	-	-	-15	-	-
DRAFT OUTLET MILL	0-2,5 kPa	-	-	-	-	-	-	0,9	-	-
POS. SEC. AIR	0-100%	70	90	90	0	0	50	65	0	0
POS. TERT. AIR	0-100%	0	0	0	0	0	0	0	0	0
POS. PRIM. AIR	0-100%	0	0	0	0	0	0	38	0	0
POS. COAL FEEDER	0-100%	0	0	0	0	0	0	50	0	0
POS. EXHAUSTER	0-100%	0	0	0	0	0	0	12	0	0
POS. OIL FLOW	0-100%	70	100	100	0	0	94	0	0	0
POS. LIMEST. FEEDER	0-100%	0	0	0	0	0	0	0	0	0
MILL LOAD	0-100A	0	0	0	0	0	0	28	0	0
CONTROL MEAS.										
POS. AIR SWIRL	0-130 MM	80	80	80	80	80	0	0	0	0
POS. CORE AIR	0-90°	90	90	45	45	45	45	0	0	0
PRESS. SEC. AIR	MM WG	90	121	126	-6	-6	32	112	-6	-6
PRESS. TERT. AIR	MM WG	-6	-6	-5	-7	-6	-5	-5	-7	-6
PRESS. CORE AIR	MM WG	9	40	12	-10	-10	-3	-10	-9	-6
PRESS. BEFORE DAMP.	MM WG	222	202	206	191	190	192	175	194	199
SEC. AIR FLOW	MM WG	19	36	32	1	1	9	16	0	1
PRIM. AIR FLOW	MM WG	0	0	0	1	1	3	43	2	2
OIL FLOW	0-100%	-	-	-	0	0	-	-	0	0
OIL PRESS. BEF. B	0-4000 kPa	3000	3000	3000	0	0	2900	1380	0	0
OIL PRESS. AFTER B	0-4000 kPa	1830	2100	2100	0	0	1600	100	0	0
UV	0-10 V	-	-	-	0	0	6	6	-	-
IR	0-10 V	-	-	-	0	0	10	9	-	-
GAS BEF. MILL	°C	-	-	-	-	-	-	166		-
POS. FEEDER	0-10	-	-	-	-	-	0	4	-	0

MEASURED VALUES AND FLUE GAS ANALYSIS
CFB GAGETOWN

READING NO.		19	20	21	22	23	24	25	26	27
DATE 1984		16.11	17.11	17.11	23.11	23.11	23.11	23.11	23.11	23.11
TIME		17:30	17:30	15:00	11:30	13:30	14:30	15:45	18:00	19:30
		COAL BR. 1 & 2	COAL BR.1	COAL BR.1						
PANEL IND.										
MW FLOW	0-25 MW	17,5	10,8	9,5	17,7	18,2	18,7	18	18,5	18,7
WATER FLOW	0-100%	65,5	42	38	66,5	68	67	66	67	66
AIR FLOW	0-100%	75,5	40	44	70	69	70	72	73,5	72
GAS INLET HEATER	0-400°C	400	302	332	370	378	383	393	364	386
GAS OUTLET HEATER	0-400°C	297	187	195	240	247	250	257	238	257
AIR INLET HEATER	0-400°C	30	30	40	40	35	35	35	35	35
AIR OUTLET HEATER	0-400°C	232	170	177	200	210	210	216	198	218
WATER INLET	0-200°C	144	144	143	140	139	140	140	139	139
WATER OUTLET	0-200°C	186	186	177	182,5	182	182	185	184	185
WATER PRESS.	0-2000 kPa	1150	1090	1070	1040	1020	1040	1100	1080	1120
O_2	0-10%	4,5	3,7	5	3,5	3,0	3,0	3,5	3,5	3,2
DRAFT FURNACE	-100/+100 Pa	-35	-40	-40	-40	-40	-40	-40	-40	-40
LOAD FD FAN	0-100 A	26	20	20	25	25	25	26	26	26
LOAD ID FAN	0-100 A	34	21	21	29	29	30	31	31	32
AIR HEATER BYPASS	0-100%	60	0	0	0	0	0	0	0	0
AIR PRESSURE	MM WG	183	200	200	200	200	200	200	200	200
CONTROL MEAS.										
PRESS. COMB. CHAMB.	MM WG	-6	-5	-5	-5	-5	-5	-5	-5	-5
O_2	%	-	-	-	4,7	4,2	-	4,0	4,5	-
BACHARACH	-	-	-	-	-	-	-	-	-	-
TEMP. BOILER HOUSE	°C	25	25	25	21	21	18	18	22	20
OUTSIDE TEMP.	°C	5	5	5	3	5	5	5	2	2
COMB. CHAMBER	°C	-	-	816	967	-	1027	1056	995	1033
LIMEST. FLOW	%	0	0	0	0	0	0	0	0	49
FLUE GAS OUTLET	°C	-	-	-	243	-	-	-	-	-

MEASURED VALUES AND FLUE GAS ANALYSIS

CFB GAGETOWN

BURNER NO. 1

READING NO.		19	20	21	22	23	24	25	26	27
DATE 1984		16.11	17.11	22.11	23.11	23.11	23.11	23.11	23.11	23.11
TIME		17:30	17:30	15:00	11:30	13:00	11:30	15:45	18:30	19:30
PANEL IND.										
TEMP. COAL/AIR	0-200°C	96	97	91	93	96	100	102	80	89
DRAFT INLET MILL	-100/+25 Pa	-20	-20	-20	-23	-20	-20	-25	-20	-18
DRAFT OUTLET MILL	0-2,5 kPa	1,1	1,2	1,4	1,2	1,15	1,15	1,15	1,2	1,3
POS. SEC. AIR	0-100%	80	80	75	70	70	70	70	70	70
POS. TERT. AIR	0-100%	50	40	40	45	45	45	55	55	55
POS. PRIM. AIR	0-100%	45	30	45	45	45	45	50	48	48
POS. COAL FEEDER	0-100%	65	80	80	70	72	73	73	75	75
POS. EXHAUSTER	0-100%	40	35	50	40	40	40	40	40	45
POS. OIL FLOW	0-100%	0	0	0	0	0	0	0	0	0
POS. LIMEST. FEEDER	0-100%	0	0	0	0	0	0	0	0	1,8
MILL LOAD	0-100A	31	35	31	29	28	27	29	32	31
CLASSIFIER	0-	-	-	-	0	0	0	0	0	0
MILL BYPASS	0-100%	-	-	100	100	100	100	100	100	100
CONTROL MEAS.										
POS. AIR SWIRL	0-130 MM	0	0	0	0	0	0	0	0	0
POS. CORE AIR	0-90°	0	0	0	0	0	0	0	0	0
PRESS. SEC. AIE	MM WG	80	95	87	63	-	60	55	55	56
PRESS. TERT. AIR	MM WG	55	40	44	52	-	50	80	83	80
PRESS. CORE AIR	MM WG	-15	-15	-17	-15	-	-18	-18	-20	-18
PRESS. BEFORE DAMP.	MM WG	130	170	170	150	-	150	145	142	142
SEC. AIR FLOW	MM WG	30	33	29	24	25	24	28	28	28
PRIM. AIR FLOW	MM WG	24	8	25	25	25	23	31	30	30
OIL FLOW	0-100%	def.	0	4	4	4	4	4	4	4
OIL. PRESS. BEF. B	0-4000 kPa	1200	0	1300	1250	1250	1250	1250	1250	1250
OIL PRESS. AFTER B	0-4000 kPa	100	0	100	100	100	100	100	100	100
UV	0-10 V	8	0	5	4	4	3	4	4	5
IR	0-10 V	10	10	10	10	10	10	10	10	10
GAS BEF. MILL	°C	-	-	214	235	-	233	-	237	286
POS. FEEDER	0-10	5,4	6,4	6,4	5,6	5,7	5,9	5,9	6	6

MEASURED VALUES AND FLUE GAS ANALYSIS

CFB GAGETOWN

BURNER NO. 2

READING NO.		19	20	21	22	23	24	25	26	27
DATE 1984		16.11	17.11	22.11	23.11	23.11	23.11	23.11	23.11	23.11
TIME		17:30	17:30	15:00	11:30	13:00	14:30	15:45	18:00	19:30
PANEL IND.										
TEMP. COAL/AIR	0-200°C	99	-	-	106	116	104	104	94	88
DRAFT INLET MILL	-100/+25 Pa	-20	-	-	-15	-15	-20	-25	-30	-25
DRAFT OUTLET MILL	0-2,5 kPa	1,0	-	-	1,15	1,15	1,2	1,2	1,3	1,2
POS. SEC. AIR	0-100%	70	0	0	65	65	65	65	65	65
POS. TERT. AIR	0-100%	60	0	0	40	35	40	45	45	45
POS. PRIM. AIR	0-100%	35	0	0	35	35	35	35	35	37
POS. COAL FEEDER	0-100%	65	0	0	67	70	73	73	75	75
POS. EXHAUSTER	0-100%	10	0	0	17	18	17	17	17	15
POS. OIL FLOW	0-100%	0	0	0	0	0	0	0	0	0
POS. LIMEST. FEEDER	0-100%	0	0	0	0	0	0	0	0	1,8
MILL LOAD	0-100A	31	0	0	22	24	23	24	24	24
CLASSIFIER	0-	-	-	-	2	2	0	0	0	0
MILL BYPASS	0-100%	-	-	-	100	100	100	100	100	100
CONTROL MEAS.										
POS. AIR SWIRL	0-130 MM	0	0	0	0	0	0	0	0	0
POS. CORE AIR	0-90°	0	0	0	0	0	0	0	0	0
PRESS. SEC. AIE	MM WG	100	-10	-8	100	-	101	100	100	95
PRESS. TERT. AIR	MM WG	70	-10	-8	32	-	30	39	40	39
PRESS. CORE AIR	MM WG	-10	-10	-10	-10	-	015	-15	-15	-10
PRESS. BEFORE DAMP.	MM WG	140	190	193	160	-	160	156	154	155
SEC. AIR FLOW	MM WG	30	1,5	1	26	23	26	27	27	27
PRIM. AIR FLOW	MM WG	27	3	2	25	26	27	27	27	35
OIL FLOW	0-100%	4	0	0	def.	def.	def.	def.	def.	def.
OIL. PRESS. BEF. B	0-4000 kPa	1400	0	0	1350	1350	1350	1350	1350	1350
OIL PRESS. AFTER B	0-4000 kPa	100	0	0	100	100	100	100	100	100
UC	0-10V	6	0	-	3	3	3	3	3	3
IR	0-10V	10	0	-	10	10	10	10	10	10
GAS FEB. MILL	°C	-	-	-	308	-	194	-	204	211
POS. FEEDED	0-10	5,3	0	0	5,6	5,7	5,9	5,9	6	6

MEASURED VALUES AND FLUE GAS ANALYSIS

CFB GAGETOWN

READING NO.		28	29	30	31	32	33	34	35	36
DATE 1984		23.11	23.11	24.11	24.11	24.11	24.11	24.11	24.11	24.11
TIME		21:00	22:45	12:00	11:45	17:00	18:00	19:00	20:00	20:45
PANEL IND.										
MW FLOW	0-25 MW	18,4	17,5	17,2	17,5	11	10,8	10,8	11	11
WATER FLOW	0-100%	66	66,5	66	66,5	42	42	42	42	42
AIR FLOW	0-100%	72	70	71,5	7,5	35	35	35	35	34
GAS INLET HEATER	0-400°C	392	388	365	382	310	320	324	328	328
GAS OUTLET HEATER	0-400°C	261	259	240	252	185	182	190	193	193
AIR INLET HEATER	0-400°C	35	35	35	35	35	35	35	35	35
AIR OUTLET HEATER	0-400°C	224	222	202	212	170	177	179	181	183
WATER INLET	0-200°C	140	143	143	142	142	142	142	144	144
WATER OUTLET	0-200°C	185	186	184	184	185	184	182	186	186
WATER PRESS.	0-2000 kPa	1110	1090	1080	1085	1040	1020	1015	1080	1120
O_2	0-10%	3,3	4,0	4,0	3,5	4,0	4,5	4,4	4,5	4,2
DRAFT FURNACE	-100/+100 Pa	-40	-40	-40	-40	-40	-40	-40	-40	-40
LOAD FD FAN	0-100 A	26	25	26	26	19	19	19	19	19
LOAD ID FAN	0-100 A	32	31	30	31	20	20	20	21	21
AIR HEATER BYPASS	0-100%	0	0	0	0	0	0	0	0	0
AIR PRESSURE	MM WG	200	200	200	200	200	200	200	200	200
CONTROL MEAS.										
PRESS. COMB. CHAMB.	MM WG	-5	-5	-5	-5	-5	-5	-5	-5	-5
O_2	%	4,3	-	-	-	-	5,7	-	-	-
BACHARACH	-	-	-	-	-	-	-	-	-	-
TEMP. BOILER HOUSE	°C	25	27	20	24	23	22	23	24	23
OUTSIDE TEMP.	°C	2	2	3	4	3	2	2	2	1
COMB. CHAMBER	°C	1004	1023	796	-	-	-	-	-	-
LIMEST. FLOW	%	50	60	0	62	0	0	0	0	0
FLUE GAS OUTLET	°C	-	-	-	-	-	-	-	-	-

MEASURED VALUES AND FLUE GAS ANALYSIS

CFB GAGETOWN

BURNER NO. 1

READING NO.		28	29	30	31	32	33	34	35	36
DATE 1984		23.11	23.11	24.11	24.11	24.11	24.11	24.11	24.11	24.11
TIME		21:00	22:45	12:00	12:45	17:00	18:00	19:00	20:00	20:45
PANEL IND.										
TEMP. COAL/AIR	0-200°C	88	89	97	94	88	93	94	90	94
DRAFT INLET MILL	-100/+25 Pa	-20	-25	-20	-30	-20	-20	-20	-20	-20
DRAFT OUTLET MILL	0-2,5 kPa	1,3	1,3	1,2	1,1	1,4	1,4	1,4	1,4	1,4
POS. SEC. AIR	0-100%	70	70	70	70	70	70	70	70	65
POS. TERT. AIR	0-100%	55	50	50	50	40	40	40	40	40
POS. PRIM. AIR	0-100%	48	48	45	45	50	50	50	50	50
POS. COAL FEEDER	0-100%	73	65	65	67	68	65	65	65	65
POS. EXHAUSTER	0-100%	45	45	40	40	35	35	35	35	35
POS. OIL FLOW	0-100%	0	0	0	0	0	0	0	0	0
POS. LIMEST. FEEDER	0-100%	-	-	-	-	-	-	-	-	-
MILL LOAD	0-100A	30	29	29	28	30	29	28	27	27
CLASSIFIER	0-6	0	0	0	0	0	0	0	0	0
MILL BYPASS OPEN	0-100%	100	100	100	100	60	60	60	60	60
CONTROL MEAS.										
POS. AIR SWIRL	0-130 MM	0	0	0	0	0	0	0	0	0
POS. CORE AIR	0-90°	0	0	0	0	0	0	0	0	0
PRESS. SEC. AIE	MM WG	-	-	-	-	-	-	-	-	-
PRESS. TERT. AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. CORE AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. BEFORE DAMP.	MM WG	-	-	-	-	-	-	-	-	-
SEC. AIR FLOW	MM WG	28	26	28	26	25	25	25	25	23
PRIM. AIR FLOW	MM WG	31	33	22	26	36	35	37	37	37
OIL FLOW	0-100%	4	4	2	2	4	4	4	4	4
OIL. PRESS. BEF. B	0-4000 kPa	1200	1200	1250	1250	1250	1250	1250	1250	1250
OIL PRESS. AFTER B	0-4000 kPa	100	100	100	100	100	100	100	100	100
UV	0-10V	5	5	4	4	5	5	5	5	5
IR	0-10V	10	10	10	10	10	10	10	10	10
GAS BEF. MILL	°C	268	259	224		191	188	-	192	182
POS. FEEDER	0-10	6	5,5	5,2	5,4	5,6	5,5	5,5	5,5	5,5

MEASURED VALUES AND FLUE GAS ANALYSIS

CFB GAGETOWN

BURNER NO. 2

READING NO.		28	29	30	31	32	33	34	35	36
DATE 1984		23.11	23.11	24.11	24.11	24.11	24.11	24.11	24.11	24.11
TIME		21:00	22:45	12:00	12:45	17:00	18:10	19:00	20:00	20:45
PANEL IND.										
TEMP. COAL/AIR	0-200°C	88	88	108	93	-	-	-	-	-
DRAFT INLET MILL	-100/+25 Pa	-25	-30	-17	-15	-	-	-	-	-
DRAFT OUTLET MILL	0-2,5 kPa	1,2	1,3	1,15	1,15	-	-	-	-	-
POS. SEC. AIR	0-100%	65	65	65	65	-	-	-	-	-
POS. TERT. AIR	0-100%	45	40	40	40	-	-	-	-	-
POS. PRIM. AIR	0-100%	37	35	35	35	-	-	-	-	-
POS. COAL FEEDER	0-100%	65	65	65	67	-	-	-	-	-
POS. EXHAUSTER	0-100%	16	17	14	14	-	-	-	-	-
POS. OIL FLOW	0-100%	0	0	0	0	0	0	0	0	0
POS. LIMEST. FEEDER	0-100%	-	-	-	-	-	-	-	-	-
MILL LOAD	0-100A	25	29	30	29	0	0	0	0	0
CLASSIFIER	0-6	0	0	0	0	-	-	-	-	-
MILL BYPASS	0-100%	100	100	100	100	-	-	-	-	-
CONTROL MEAS.										
POS. AIR SWIRL	0-130 MM	0	0	0	0	0	0	0	0	0
POS. CORE AIR	0-90°	0	0	0	0	0	0	0	0	0
PRESS. SEC. AIE	MM WG	-	-	-	-	-	-	-	-	-
PRESS. TERT. AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. CORE AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. BEFORE DAMP.	MM WG	-	-	-	-	-	-	-	-	-
SEC. AIR FLOW	MM WG	27	25	26	25	1	0	0	0	1
PRIM. AIR FLOW	MM WG	34	33	26	27	1	1	1	1	2
OIL FLOW	0-100%	def.	def.	def.	def.	-	-	-	-	-
OIL. PRESS. BEF. B	0-4000 kPa	1300	1300	1350	1350	-	-	-	-	-
OIL PRESS. AFTER B	0-4000 kPa	100	100	100	100	-	-	-	-	-
UV	0-10V	3	3	3	3	-	-	-	-	-
IR	0-10V	10	10	10	10	-	-	-	-	-
GAS BEF. MILL	°C	21								

MEASURED VALUES AND FLUE GAS ANALYSIS

CFB GAGETOWN

READING NO.		37	38	39	40	41	42	43	44	45
DATE 1984		25.11	25.11	25.11	25.11	25.11	25.11	26.11	26.11	26.11
TIME		11:00	12:00	13:00	14:00	15:00	16:00	13:00	14:00	15:45
PANEL IND.										
MW FLOW	0-25 MW	10,8	11	10,5	10,7	10,5	10,5	17	17	16,7
WATER FLOW	0-100%	42,5	42,5	42	42,5	42,5	42	66	66	66
AIR FLOW	0-100%	34	33,5	33,3	33	33	34	66,5	66	63
GAS INLET HEATER	0-400°C	314	320	332	336	338	339	372	378	360
GAS OUTLET HEATER	0-400°C	184	197	198	200	201	202	243	248	234
AIR INLET HEATER	0-400°C	40	40	40	40	40	40	37	37	35
AIR OUTLET HEATER	0-400°C	176	184	183	186	187	184	201	203	197
WATER INLET	0-200°C	145	146	146	147	148	147	142	143	143
WATER OUTLET	0-200°C	186	186	186	188	187,5	188	183	184	184
WATER PRESS.	0-2000 kPa	1100	1100	1110	1110	1100	1100	1090	1100	1070
O_2 (WET)	0-10%	4,0	4,5	5,2	4,0	3,8	3,5	4,0	3,5	4,0
DRAFT FURNACE	-100/+100 Pa	-40	-40	-40	-40	-40	-40	-40	-40	-45
LOAD FD FAN	0-100 A	19	19	19	19	19	19	25	25	24
LOAD ID FAN	0-100 A	20	20	20	20	21	21	30	30	28
AIR HEATER BYPASS	0-100%	0	0	0	0	0	0	0	0	0
AIR PRESSURE	MM WG	200	200	200	200	200	200	200	200	200
CONTROL MEAS.										
PRESS. COMB. CHAMB.	MM WG	-5	-5	-5	-5	-5	-5	-5	-5	-5
O_2	%	-	5,2	-	-	-	-	5,2	-	-
BACHARACH	-	-	-	-	-	-	-	-	-	-
TEMP. BOILER HOUSE	°C	24	24	23	23	22	22	24	24	23
OUTSIDE TEMP.	°C	0	2	4	4	5	6	8	8	9
COMB. CHAMBER	°C	-	-	-	-	-	-	-	-	-
LIMEST. FLOW	%	0	31	31	30	31	31	0	0	28

MEASURED VALUES AND FLUE GAS ANALYSIS

CFB GAGETOWN

BURNER NO. 1

READING NO.		37	38	39	40	41	42	43	44	45
DATE 1984		25.11	25.11	25.11	25.11	25.11	25.11	26.11	26.11	26.11
TIME		11:00	12:00	13:00	14:00	15:00	16:00	13:00	14:00	15:45
PANEL IND.										
TEMP. COAL/AIR	0-200°C	93	90	94	91	90	92	90	93	91
DRAFT INLET MILL	-100/+25 Pa	-30	-25	-25	-20	-22	-20	-30	-25	-25
DRAFT OUTLET MILL	0-2,5 kPa	1,4	1,5	1,45	1,4	1,4	1,4	1,3	1,3	1,3
POS. SEC. AIR	0-100%	65	65	65	65	65	65	70	70	70
POS. TERT. AIR	0-100%	40	40	40	40	40	44	35	35	25
POS. PRIM. AIR	0-100%	45	50	50	50	50	50	55	55	55
POS. COAL FEEDER	0-100%	68	68	68	67	67	67	65	67	68
POS. EXHAUSTER	0-100%	35	35	35	35	35	35	30	30	30
POS. OIL FLOW	0-100%	0	0	0	0	0	0	0	0	0
POS. LIMEST. FEEDER	0-100%	0	-	-	-	-	-	-	-	-
MILL LOAD	0-100A	28	28	28	29	29	26	27	29	31
CLASSIFIER	0-6	0	0	0	0	0	0	0	0	0
MILL BYPASS	0-100%	60	60	60	60	60	60	50	50	50
CONTROL MEAS.										
POS. AIR SWIRL	0-130 MM	0	0	0	0	0	0	0	0	0
POS. CORE AIR	0-90°	0	0	0	0	0	0	0	0	0
PRESS. SEC. AIE	MM WG	-	-	-	-	-	-	-	-	-
PRESS. TERT. AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. CORE AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. BEFORE DAMP.	MM WG	-	-	-	-	-	-	-	-	-
SEC. AIR FLOW	MM WG	22	22	22	22	23	24	21	21	19
PRIM. AIR FLOW	MM WG	25	38	38	38	38	38	54	52	53
OIL FLOW	0-100%	4	4	4	4	4	4	4	4	4
OIL PRESS. BEF. B	0-4000 kPa	1200	1200	1200	1200	1200	1200	1250	1250	1250
OIL PRESS. AFTER B	0-4000 kPa	100	100	100	100	100	100	100	100	100
UV	0-10V	5	5	5	6	6	6	7	7	6
IR	0-10V	10	10	10	10	10	10	10	10	10
GAS BEF. MILL	°C	171	169	164	225	222	239	204	232	228
POS. FEEDER	0-10	5,6	5,6	5,6	5,6	5,6	5,6	5,4	5,5	5,5

MEASURED VALUES AND FLUE GAS ANALYSIS

CFB GAGETOWN

BURNER NO. 2

READING NO.		37	38	39	40	41	42	43	44	45
DATE 1984		25.11	25.11	25.11	25.11	25.11	25.11	26.11	26.11	26.11
TIME		11:00	12:00	13:00	14:00	15:00	16:00	13:00	14:00	15:45
PANEL IND.										
TEMP. COAL/AIR	0-200°C	-	-	-	-	-	-	92	90	88
DRAFT INLET MILL	-100/+25 Pa	-	-	-	-	-	-	-25	-25	-25
DRAFT OUTLET MILL	0-2,5 kPa	-	-	-	-	-	-	1,3	1,3	1,4
POS. SEC. AIR	0-100%	0	0	0	0	0	0	60	60	60
POS. TERT. AIR	0-100%	0	0	0	0	0	0	38	37	25
POS. PRIM. AIR	0-100%	0	0	0	0	0	0	40	40	40
POS. COAL FEEDER	0-100%	0	0	0	0	0	0	65	67	68
POS. EXHAUSTER	0-100%	0	0	0	0	0	0	16	16	17
POS. OIL FLOW	0-100%	0	0	0	0	0	0	0	0	0
POS. LIMEST. FEEDER	0-100%	0	0	0	0	0	0	-	-	-
MILL LOAD	0-100A	0	0	0	0	0	0	25	25	29
CLASSIFIED	0-6	0	0	0	0	0	0	0	0	0
MILL BYPASS	0-100%	-	-	-	-	-	-	50	50	50
CONTROL MEAS.										
POS. AIR SWIRL	0-130 MM	0	0	0	0	0	0	0	0	0
POS. CORE AIR	0-90°	0	0	0	0	0	0	0	0	0
PRESS. SEC. AIE	MM WG	-	-	-	-	-	-	-	-	-
PRESS. TERT. AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. CORE AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. BEFORE DAMP.	MM WG	-	-	-	-	-	-	-	-	-
SEC. AIR FLOW	MM WG	0	0	1	0,5	1	0,5	23	23	18,5
PRIM. AIR FLOW	MM WG	2	2	2	1	1	1	49	52	53
OIL FLOW	1-5 V	-	-	0	0	0	0	def.	def.	def.
OIL. PRESS. BEF. B	0-4000 kPa	0	0	0	0	0	0	1350	1350	1350
OIL PRESS. AFTER B	0-4000 kPa	0	0	0	0	0	0	100	100	100
UV	0-10V	-	-	-	-	-	-	3	3	4
IR	0-10V	-	-	-	-	-	-	10	10	10
GAS BEF. MILL	°C	-	-	-	-	-	-	191	206	194
POS. FEEDER	0-10	0	0	0	0	0	0	5,4	5,5	5,5

MEASURED VALUES AND FLUE GAS ANALYSIS

CFB GAGETOWN

READING NO.		46	47	48	49
DATE 1984		26.1	28.11	28.11	18.11
TIME		16:45	11:00	13:00	14:00
PANEL IND.					
MW FLOW	0-25 MW	16,5	16,5	16	16,5
WATER FLOW	0-100%	67	66	66	66
AIR FLOW	0-100%	64	64	64	64
GAS INLET HEATER	0-400°C	370	367	396	396
GAS OUTLET HEATER	0-400°C	243	249	250	261
AIR INLET HEATER	0-400°C	35	45	40	40
AIR OUTLET HEATER	0-400°C	202	198	210	219
WATER INLET	0-200°C	144	142	140	142
WATER OUTLET	0-200°C	184	182	180	182
WATER PRESS.	0-2000 kPa	1080	1050	1050	1020
O_2	0-10%	3,8	3,8	4,0	3,5
DRAFT FURNACE	-100/+100 Pa	-45	-40	-45	-40
LOAD FD FAN	0-100 A	24	24	24	25
LOAD ID FAN	0-100 A	28	28	29	29
AIR HEATER BYPASS	0-100%	0	0	0	0
AIR PRESSURE	MM WG	200	200	200	200
CONTROL MEAS.					
PRESS. COMB. CHAMB.	MM WG	-6	-5	-5	-5
O_2	%	-	-	-	-
BACHARACH	-	-	-	-	-
TEMP. BOILER HOUSE	°C	23	24	24	24
OUTSIDE TEMP.	°C	7	5	9	10
COMB. CHAMBER	°C	-	-	-	-
LIMEST. FLOW	%	28	45	50	52

MEASURED VALUES AND FLUE GAS ANALYSIS
CFB GAGETOWN

BURNER NO. 1

READING NO.		46	47	48	49
DATE 1984		26.11	28.11	28.11	28.11
TIME		16:45	11:00	13:00	14:00
PANEL IND.					
TEMP. COAL/AIR	0-200°C	92	96	92	93
DRAFT INLET MILL	-100/+25 Pa	-25	-20	-20	-20
DRAFT OUTLET MILL	0-2,5 kPa	1,3	1,4	1,3	1,3
POS. SEC. AIR	0-100%	70	70	70	70
POS. T					
TEXTE MANQUE					
19	20	21,5			
PRIM. AIR FLOW	MM WG	53	50	50	52
OIL FLOW	1-5 V	4	-	-	-
OIL PRESS. BEF. B	0-4000 kPa	1250	1200	1200	1200
OIL PRESS. AFTER B	0-4000 kPa	100	100	100	100
UV	0-10V	6	6	6	6
IR	0-10V	10	10	10	10
GAS BEF. MILL	°C	251	272	254	264
POS. FEEDER	0-10	5,5	5,1	5,2	5,2

MEASURED VALUES AND FLUE GAS ANALYSIS

CFB GAGETOWN

BURNER NO. 2

READING NO.		46	47	48	49
DATE 1984		26.11	28.11	28.11	28.11
TIME		16:45	11:00	13:00	12:00
PANEL IND.					
TEMP. COAL/AIR	0-200°C	92	96	92	94
DRAFT INLET MILL	-100/+25 Pa	-25	-25	-30	-30
DRAFT OUTLET MILL	0-2,5 kPa	1,4	1,3	1,3	1,3
POS. SEC. AIR	0-100%	60	62	61	61
POS. TERT. AIR	0-100%	30	30	31	30
POS. PRIM. AIR	0-100%	40	42	40	40
POS. COAL FEEDER	0-100%	68	60	62	68
POS. EXHAUSTER	0-100%	18	16	17	17
POS. OIL FLOW	0-100%	0	0	0	0
POS. LIMEST. FEEDER	0-100%	-	-	-	-
MILL LOAD	0-100A	28	28	28	28
CLASSIFIER	0-6	0	0	0	0
MILL BYPASS	0-100%	50	50	50	50
CONTROL MEAS.					
POS. AIR SWIRL	0-130 MM	0	0	0	0
POS. CORE AIR	0-90°	0	0	0	0
PRESS. SEC. AIE	MM WG	-	-	-	-
PRESS. TERT. AIR	MM WG	-	-	-	-
PRESS. CORE AIR	MM WG	-	-	-	-
PRESS. BEFORE DAMP.	MM WG	-	-	-	-
SEC. AIR FLOW	MM WG	19	19	19	21
PRIM. AIR FLOW	MM WG	52	53	52	51
OIL FLOW	1-5 V	-	-	-	-
OIL PRESS. BEF. B	0-4000 kPa	1350	1350	1350	1350
OIL PRESS. AFTER B	0-4000 kPa	100	100	100	100
UV	0-10V	4	3	3	3
IR	0-10V	10	10	10	10
GAS BEF. MILL	°C	208	196	208	216
POS. FEEDER	0-10	5,5	5,1	5,2	5,2

13.4 ENVIRONMENT CANADA EMISSION DATA

THE FOLLOWING THREE PAGES SUMMARIZE:

- AVERAGE CONCENTRATIONS FOR SO_2, NO_x, CO, THC AND O_2 AS MEASURED BY CONTINUOUS MONITORS.
- CONCENTRATIONS OF SO_2 AND NO_x AS MEASURED BY STANDARD REFERENCE METHODS.
- CONCENTRATIONS OF PARTICULATE MATTER AS MEASURED BY THE STANDARD REFERENCE METHOD.

SUMMARY OF GAS CONCENTRATION DATA

DATE	UNIT	LOAD	LIMESTONE	CONCENTRATION OF GASES				
				SO_2	NO_x *	CO *	THC *	O_2 +
Nov. 23	2	≈ 100	no	2450.	245.	68.	<5	4.90
	2	≈ 100	yes	1136.	254.	54.	<5	5.60
Nov. 27	1	≈ 100	no	2087.	567.	10.	<5	4.97
Nov. 28	2	≈ 100	yes	1169.	212.	78.	<5	5.62
	3	≈ 100	yes	1047.	211.	67.	<5	5.49

* - ppm, dry basis - corrected to 3% O_2.

+ - %, dry basis

ENVIRONMENT CANADA

COMPARISON OF STANDARD REFERENCE METHOD & CONTINUOUS MONITORING GAS CONCENTRATIONS - SO_2

SO_2 Test No.	Date	Conditions	Concentration of SO_2 (dry, ppm) SRM *	CSM
1	Nov. 23	100%, no limestone	2117	2154
2	Nov. 23	100%, no limestone	2218	2190
3	Nov. 23	100% with limestone	1011	1019
4	Nov. 23	100% with limestone	996	1002

COMPARISON OF STANDARD REFERENCE METHOD & CONTINUOUS MONITORING GAS CONCENTRATIONS - NO_x

NO_x Test No.	Date	Conditions	Concentration of NO_x (dry, ppm) SRM	CSM
1	Nov. 23	100% load	191	
2	Nov. 23	with	209	Average
3	Nov. 23	limestone	217	217 ppm
4	Nov. 23	injection	209	

Mean = 206.5

PARTICULATE STANDARD REFERENCE TESTING RESULTS

Date	Unit	Load (%)	Limestone	Run	Concentration (g/m^3)+	Mass Flux kg/h
23	2	= 100	no	1	4.27	110.
				2	4.19	114.
	2	= 100	yes	3	10.21	284.
				4	10.30	283.
24	2	= 50	no	5	3.86	61.2
				6	3.84	59.9
25	2	= 50	yes	7	7.08	106.
				8	8.34	127.
26	2	= 100	no	9	4.02	106.
			yes	10	6.00	154.
27	1	= 100	no	11 *	3.20	87.1
				12	3.68	95.6
				13	3.37	87.6

+ - dry basis at 25°C and 101.3 kPa.

* - Invalid Test.

ENVIRONMENT CANADA

13.5 TEST SERIES 2 - BOILER PERFORMANCE DATA

EVALUATION OF READINGS BURNERS NO. 1 & 2
CFB GAGETOWN

READING NO.		1	2	3	4	5	6	7	8	9
DATE 1985		23.3	24.3	24.3	24.3	24.3	25.3	25.3	26.3	26.3
TIME		15:00	14:00	16:00	17:00	18:30	14:30	15:30	10:00	14:30
PANEL IND.		BR.1 -	BR.1 BR.2	BR.1 BR.2	BR.1 BR.2	BR.1 -	BR.1 -	BR.1 -	BR.1 -	BR.1 -
MW FLOW	0-25 MW	10,3	11	16	17	10	4,8	5,2	7	11
WATER FLOW	0-100%	40	48	73	74	51	34	34	40	47
AIR FLOW	0-100%	41	52	73	74	37	27	24	29	43
GAS INLET HEATER	0-400°C	230	250	308	272	203	170	170	180	190
GAS OUTLET HEATER	0-400°C	358	396	+400	405	370	290	290	310	320
AIR INLET HEATER	0-400°C	30	30	30	30	27	24	26	26	25
AIR OUTLET HEATER	0-400°C	200	200	232	206	183	160	166	177	176
WATER INLET	0-200°C	141	149	148	143	142	138	138	140	144
WATER OUTLET	0-200°C	174	186	182	180	174	162	164	168	180
WATER PRESSURE	0-2000kPa	1090	1100	1010	1000	1000	1000	1060	1050	1070
O_2	0-10	6,5	6,5	5,5	5,8	5,9	9,5	7,8	6,5	5,6
DRAFT FURNACE	-100/+100Pa	-40	-45	-50	-45	-50	-60	-60	-50	-50
LOAD FD FAN	0-100 A	21	23	27	27	20	20	20	20	21
LOAD ID FAN	0-100 A	23	24	34	33	21	18	18	18	21
AIR HEATER BYPASS	0-100%	75	60	0	0	5	0	0	0	0
AIR PRESSURE	MMWG	200	200	175	170	200	200	200	200	200
CONTROL MEAS.										
PRESS.COMB.CHAMB.	MM WG	-	-	-	-	-	-	-	-	-
O_2	%	-	-	-	-	-	-	-	-	-
BACHARACH	-	-	-	-	-	-	-	-	-	-
TEMP. BOILERHOUSE	°C	23	26	26	28	27	24	27	22	24
OUTSIDE TEMP.	°C	8	4	6	5	3	1	4	-4	0

EVALUATION OF READINGS BURNER NO. 1
CFB GAGETOWN

READING NO.		1	2	3	4	5	6	7	8	9
DATE 1985		23.3	24.3	24.3	24.3	24.3	25.3	25.3	26.3	26.3
TIME		15:00	14:00	16:00	17:00	18:30	14:30	15:30	10:00	14:30
PANEL IND.										
TEMP. COAL/AIR	0-200°C	92	90	102	102	99	108	109	103	100
DRAFT INLET MILL	-100/+25 Pa	-20	-15	-20	-20	-20	-20	-20	-20	-25
DRAFT OUTLET MILL	0-2,5 kPa	1,5	0,8	1,0	0,9	1,2	0,8	0,8	0,9	1,5
POS. SEC. AIR	0-100%	75	60	75	75	70	65	60	65	75
POS. TERT. AIR	0-100%	50	20	60	60	50	0	0	20	60
POS. PRIM. AIR	0-100%	57,5	52	58	58	50	35	40	50	55
POS. COAL FEEDER	0-100%	85	55	75	78	85	50	50	65	85
POS. EXHAUSTER	0-100%	30	10	17	16	23	11	11	15	30
POS. OIL FLOW l/hr	0-100%	±50	±50	±50	±50	±50	±50	±50	±50	±50
POS. LIMEST. FEEDER	0-100%	0	0	0	0	0	0	0	0	0
MILL LOAD	0-100A	33	23	31	31	33	21	23	28	34
CLASSIFIER	0-6	0	0	0	0	0	0	0	0	0
MILL BYPASS OPEN	0-100%	0	0	0	0	0	0	0	10	10
FLUE GAS CONE OPEN	0-100%	100	100	100	100	100	100	100	100	100
CONTROL MEAS.										
POS. AIR SWIRL	0-130 MM	65	65	65	65	65	65	65	65	65
POS. CORE AIR	0-90°	0	0	0	0	0	0	0	0	0
PRESS. SEC. AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. TERT. AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. CORE AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. BEFORE DAMP.	MMWG	-	-	-	-	-	-	-	-	-
SEC. AIR FLOW	MMWG Delt P	34	13	29	28	28	12	10	17	37
PRIM. AIR FLOW	MMWG Delt P	55	31	37	38	29	8	8	28	44
OIL FLOW	1-5 V	-	-	-	-	-	-		-	-
OIL PRESS. BEF. B	0-4000 kPa	1300	1300	1300	1300	1300	1300	1300	1300	1300
OIL PRESS. AFTER B	0-4000 kPa	100	100	100	100	100	100	100	100	100
VV	0-10V	3	3	3	3	3	3	3	3	3
IR	0-10V	10	10	10	10	10	10	10	10	10
POS. FEEDER	0-10	7,5	4,9	6,5	6,7	7,4	4,5	4,5	5,8	7,5

EVALUATION OF READINGS BURNER NO. 2

CFB GAGETOWN

READING NO.		1	2	3	4	5	6	7	8	9
DATE 1985		23.3	24.3	24.3	24.3	24.3	25.3	25.3	26.3	26.3
TIME		15:00	14:00	16:00	17:00	18:30	14:30	15:30	10:00	14:30
PANEL IND.										
TEMP. COAL/AIR	0-200°C	-	86	100	103	-	-	-		
DRAFT INLET MILL	-100/+25 Pa	-	-10	-15	-15	-	-	-		
DRAFT OUTLET MILL	0-2,5 kPa	-	0,9	1,3	1,4	-	-	-		
POS. SEC. AIR	0-100%	-	60	70	70	-	-	-		
POS. TERT. AIR	0-100%	-	20	60	60	-	-	-		
POS. PRIM. AIR	0-100%	-	47,5	54	53	-	-	-		
POS. COAL FEEDER	0-100%	-	55	80	83	-	-	-	-	
POS. EXHAUSTER	0-100%	-	25	35	35	-	-	-		
POS. OIL FLOW l/hr	0-100%	-	±50	±50	±50	-	-	-		
POS. LIMEST. FEEDER	0-100%	-	0	0	0	-	-	-		
MILL LOAD	0-100A	-	28	35	35	-	-	-		
CLASSIFIER	0-6	-	0	0	0	-	-	-		
MILL BYPASS OPEN	0-100%	-	0	0	0	-	-	-	-	
FLUE GAS CONE OPEN	0-100%	-	100	100	100	-	-	-		
CONTROL MEAS.										
POS. AIR SWIRL	0-130 MM	-	65	65	65	-	-	-		
POS. CORE AIR	0-90°	-	0	0	0	-	-	-		
PRESS. SEC. AIR	MM WG	-	-	-	-	-	-	-		
PRESS. TERT. AIR	MM WG	-	-	-	-	-	-	-		
PRESS. CORE AIR	MM WG	-	-	-	-	-	-	-		
PRESS. BEFORE DAMP.	MMWG	-	-	-	-	-	-	-		
SEC. AIR FLOW	MMWG Delt P	0	14	29	28	0	0	0	0	
PRIM. AIR FLOW	MMWG Delt P	0	31	37	37	0	0,5	0	0	
OIL FLOW	1-5 V	-	-	-	-	-	-	-		
OIL PRESS. BEF. B	0-4000 kPa	-	1300	1300	1300	-	-	-		
OIL PRESS. AFTER B	0-4000 kPa	-	100	100	100	-	-	-		
VV	0-10V	-	3	3	3	-	-	-		
IR	0-10V	-0	10	10	10	-	-	-		
POS. FEEDER	0-10	-	4,8	6,5	6,8	-	-	-		

EVALUATION OF READINGS
CFB GAGETOWN

READING NO.		10	11	12
DATE 1985		26.3	27.3	28.3
TIME		15:30	10:00	11:00
BOILER NO		Br.1 +Br.2	Br.1 +Br.2	Br.1
PANEL IND.				
MW FLOW	0-25 MW	15	12,2	9,5
WATER FLOW	0-100%	56	53	46
AIR FLOW	0-100%	68	54	40
GAS INLET HEATER	0-400°C	192	220	190
GAS OUTLET HEATER	0-400°C	379	350	320
AIR INLET HEATER	0-400°C	23	24	24
AIR OUTLET HEATER	0-400°C	192	174	170
WATER INLET	0-200°C	144	144	146
WATER OUTLET	0-200°C	186	179	179
WATER PRESS.	0-2000 kPa	1090	1080	1020
O_2	0-10%	5,5	6,5	7,5
DRAFT FURNACE	-100/+100 Pa	-50	-45	-50
LOAD FD FAN	0-100 A	27	24	21
LOAD ID FAN	0-100 A	30	25	22
AIR HEATER BYPASS	0-100%	0	0	0
AIR PRESSURE	MM WG	190	200	200
CONTROL MEAS.				
PRESS. COMB. CHAMB.	MM WG	-	-	-
O_2	%	-	-	-
BACHARACH	-	-	-	-
TEMP. BOILER HOUSE	°C	22	22	26
OUTSIDE TEMP.	°C	0	2	5

EVALUATION OF READINGS BURNER NO. 1

CFB GAGETOWN

READING NO.		10	11	12
DATE 1985		26.3	27.3	28.3
TIME		15:30	10:00	11:00
PANEL IND.				
TEMP. COAL/AIR	0-200°C	102	102	92
DRAFT INLET MILL	-100/+25 Pa	-20	-20	-20
DRAFT OUTLET MILL	0-2,5 kPa	1,1	1,1	1,2
POS. SEC. AIR	0-100%	67	64	75
POS. TERT. AIR	0-100%	50	10	50
POS. PRIM. AIR	0-100%	55	56	56
POS. COAL FEEDER	0-100%	68	57	85
POS. EXHAUSTER	0-100%	20	23	24
POS. OIL FLOW l/hr	0-100%	±50	±50	0
POS. LIMEST. FEEDER	0-100%	0	0	0
MILL LOAD	0-100A	28	27	32
CLASSIFIER	0-6	0	0	0
MILL BYPASS OPEN	0-100%	10	50	0
FLUE GAS CONE OPEN	0-100%	100	100	100
CONTROL MEAS.				
POS. AIR SWIRL	0-130 MM	65	65	65
POS. CORE AIR	0-90°	0	0	0
PRESS. SEC. AIR	MM WG	35	-	55
PRESS. TERT. AIR	MM WG	-	-	-
PRESS. CORE AIR	MM WG	-	-	-
PRESS. BEFORE DAMP.	MMWG	-	-	-
SEC. AIR FLOW	MMWG Delt P	22	14	34
PRIM. AIR FLOW	MMWG Delt P	41	45	52
OIL FLOW	1-5 V	-	-	-
OIL PRESS. BEF. B	0-4000 kPa	1300	1300	0
OIL PRESS. AFTER B	0-4000 kPa	100	100	0
VV	0-10V	4	5	0
IR	0-10V	10	10	10
POS. FEEDER	0-10	6	5,2	7,5

EVALUATION OF READINGS BURNER NO. 2

CFB GAGETOWN

READING NO.		10	11	12
DATE 1985		26.3	27.3	28.3
TIME		15:30	10:00	11:00
PANEL IND.				
TEMP. COAL/AIR	0-200°C	106	100	
DRAFT INLET MILL	-100/+25 Pa	-15	-15	
DRAFT OUTLET MILL	0-2,5 kPa	1,3	1,2	
POS. SEC. AIR	0-100%	63	60	
POS. TERT. AIR	0-100%	50	10	
POS. PRIM. AIR	0-100%	50	53	
POS. COAL FEEDER	0-100%	70	55	
POS. EXHAUSTER	0-100%	37	36	
POS. OIL FLOW l/hr	0-100%	±50	±50	
POS. LIMEST. FEEDER	0-100%	0	0	
MILL LOAD	0-100A	20	21	
CLASSIFIER	0-6	0	0	
MILL BYPASS OPEN	0-100%	10	50	
FLUE GAS CONE OPEN	0-100%	100	100	
CONTROL MEAS.				
POS. AIR SWIRL	0-130 MM	65	65	
POS. CORE AIR	0-90°	0	0	
PRESS. SEC. AIR	MM WG	-	-	
PRESS. TERT. AIR	MM WG	-	-	
PRESS. CORE AIR	MM WG	-	-	
PRESS. BEFORE DAMP.	MMWG	-	-	
SEC. AIR FLOW	MMWG Delt P	24	13	
PRIM. AIR FLOW	MMWG Delt P	35	46	
OIL FLOW	1-5 V	-	-	
OIL PRESS. BEF. B	0-4000 kPa	1300	1300	
OIL PRESS. AFTER B	0-4000 kPa	100	100	
VV	0-10V	2	3	
IR	0-10V	10	10	
POS. FEEDER	0-10	6	4,5	

13.6 TEST SERIES 3 - BOILER PERFORMANCE DATA

Test	Date Dec.	Time	Load (MW)	Lime-stone Feed Rate kg/hr	Temperature Air Heater Air in (C)	Temperature Air Heater Gas out (C)	% C in Fly Ash	% 0_2 (dry)	Oil Flow L/hr
1	2	1130-1230	10.5	0	30.3	207.0		7.1	100.0
2	2	1400-1545	10.0	139.7	30.3	221.3		0.0	100.0
3	2	1615-1800	10.4	312.1	32.7	229.0		7.7	100.0
4	3	1400-1500	15.75	0	21.5	244.5		3.1	50.0
5	3	1630-1830	15.4	258.3	19.0	254.0		4.4	50.0
6	3	1845-2030	15.1	361.2	20.0	263.0		4.2	50.0

(BRITISH UNITS)

Test	Date Dec.	Time	Load MBTU per hr	Lime-stone Feed Rate lb/hr	Temperature Air Heater Air in (F)	Temperature Air Heater Gas out (F)	% C in Fly Ash	% 0_2 (dry)	Oil Flow USGPM
1	2	1130-1230	35.8	0	86.6	404.6		7.1	0.4
2	2	1400-1545	34.1	308.08	86.6	430.4		8.0	0.4
3	2	1615-1800	35.5	688.04	90.8	444.2		7.7	0.4
4	3	1400-1500	53.8	0	70.7	472.1		3.1	0.2
5	3	1630-1830	52.5	569.41	66.2	489.2		4.4	0.2
6	3	1845-2030	51.6	796.37	68.0	505.4		4.2	0.2

Nov. 23, Evening 100% Load

Hr	Time Min.	Sec.	Totalizer kg	IMPACT PLATE Feedrate kg/hr *	Feedrate kg/hr Subtract Totalizer Reading 5 Periods Previous	Feedrate %	STAR FEEDER RPM %
18	31	10	1240.0			100	
18	53	30	1629.3	1045.9		73	
19	6	40	1797.0	764.2		66	
19	12	15	1865.0	730.7		57	
19	23	0	1996.0	731.2		52	
21	8	0	3340.0	768.0	803.4	68	57
21	17	0	3469.0	860.0	769.2	66	57
21	26	0	3593.0	832.7	773.8	65	58
21	35	0	3720.0	840.7	779.7	66	59
21	51	0	3930.0	787.5	784.1	62	59
22	2	0	4035.0	572.7	772.2	62	60
22	11	0	4160.0	833.3	767.8	62	59
22	19	0	4255.0	712.5	748.4	64	58
22	26	0	4335.0	685.7	723.5	61	60
22	35	0	4443.8	725.3	700.6	62	61
22	40	0	4507.0	758.4	745.3	63	60
22	53	0	4715.5	962.3	793.6	60	62.5
23	7	0	4840.2	534.4	731.5	63	60.5
23	26	0	5077.0	747.8	742.0	62	60.5
23	30	0	5138.0	915.0	757.3	62	62.5
23	40	0	5250.0	672.0	743.0	61	63
23	50	0	5375.0	750.0	694.2	62	62.5
24	0	0	5498.0	738.0	744.7	61	62.7
Kg/hr, End - Beginning readings:					776.9		

* Calculated by subtracting the immediate previous reading and time from the current reading and time.

Nov. 24: Unit 2, Min. Oil, 100% Load, for just 1 hr. before mill fire

Hr	Time Min.	Sec.	Totalizer kg	IMPACT PLATE Feedrate kg/hr *	Feedrate kg/hr Subtract Totalizer Reading 3 Periods Previous	Feedrate %	STAR FEEDER RPM %
12	35	0	6130			62	61
12	41	0	6201	710.0		61	51
12	50	0	6313	746.7		60	57
13	8	0	6510	656.7	690.9	29	32

LIMESTONE FEEDRATES

Nov. 25: 50% Load, Unit 2, Min. Oil, Limestone feedrate set at approx. 360 kg/hr.

Time Hr	Min.	Sec.	Totalizer kg	IMPACT PLATE Feedrate kg/hr *	Feedrate kg/hr Subtract Totalizer Reading 5 Periods Previous	Feedrate %	STAR FEEDER RPM %
11	21	0	14.1			33	11
11	29	0	62.0	359.3		49	27
11	37	0	125.0	472.5		26	32
11	46	0	180.0	366.7		30	42
11	59	0	253.2	337.8		32	51.5
12	9	0	297.0	262.8	353.6	31	49
12	14	0	353.0	672.0	388.0	31	44
12	19	0	384.0	372.0	370.0	31	48
12	41	0	527.0	390.0	378.5	29	50
13	2	0	652.0	357.1	379.8	32	51
13	8	0	690.0	380.0	399.7	30	52
13	21	0	770.5	371.5	373.9	30	50
13	28	0	841.5	608.6	397.8	31	58
13	39	0	904.0	340.9	390.0	30	51
13	52	0	969.0	300.0	380.4	29	50
14	0	0	1012.6	327.0	372.2	30	51
14	22	0	1148.8	371.5	372.1	30	50
14	27	0	1182.0	398.4	346.3	30	53
14	41	0	1265.9	359.6	350.2	30	52
14	51	0	1327.0	366.6	364.1	29	54
15	8	0	1432.0	370.6	370.1	30	52
15	24	0	1531.0	371.3	369.9	31	54
15	27	0	1549.5	370.0	367.5	30	54
15	34	0	1592.3	366.9	369.5	31	52
16	13	0	1832.0	368.8	369.5	30	48

Kg/hr, End - Beginning readings: 373.5

* Calculated by subtracting the immediately previous totalizer reading and time from the reading and time on the current line.

LIMESTONE FEEDRATES

Nov. 26: Low Sulphur Coal, Unit 2, 100% Load, Min. Oil.

Time Hr	Min.	Sec.	Totalizer kg	IMPACT PLATE Feedrate kg/hr *	Feedrate kg/hr Subtract Totalizer Reading 5 Periods Previous	Feedrate %	STAR FEEDER RPM %	
15	27	0	2084.0			28	37	
15	33	0	2117.0	330.0		26	36	
15	40	0	2155.0	325.7		27	37.5	
15	58	0	2258.0	343.3		28	45	
16	26	0	2420.0	347.1		29	47	
16	33	0	2462.0	360.0	343.6	29	51	
16	41	0	2508.0	345.0	345.0	27	47.5	
16	45	0	2531.0	345.0	347.1	28	48	
16	57	0	2601.0	350.0	348.8	28	49	
17	9	0	2662.0	305.0	337.7	12	24	Feed
17	20	0	2691.2	159.3	292.6	12	24	Slow
17	39	0	2741.0	157.3	241.0	11	19	Down
17	48	0	2779.7	258.0	236.9	30	41	
18	4	0	2882.0	383.6	251.6	31	46	

Kg/hr, End - Beginning readings: 305.0

* Calculated by sustracting the immediately previous totalizer reading and time from the reading and time on the current line.

LIMESTONE FEEDRATES

Nov. 26: Low Sulphur Coal, Unit 2, 100% Load, Min. Oil.

Time Hr	Min.	Sec.	Totalizer kg	IMPACT PLATE Feedrate kg/hr *	Feedrate kg/hr Subtract Totalizer Reading 5 Periods Previous	Feedrate %	STAR FEEDER RPM %	
						0	0	
11	8	0	153.8			48	42	
11	13	0	198.9	541.2		45	49	
11	23	0	288.6	538.2		44	58	
11	35	0	397.3	543.5		44	56	
11	51	0	541.5	540.8		47	56	
11	53	0	XXX	***	***	51	62	Feedrate
12	12	0	747.9	***	558.3	50	63	increased
12	33	0	958.5	601.7	574.2	48	63	at 11:55:3
12	42	0	1049.2	604.7	583.8	50	62	
12	53	0	1161.1	610.4	599.6	51	64	
13	14	0	XXX	***	***	52	64	
13	26	0	1505.2	***	614.0	52	64	
13	44	0	1695.3	633.7	622.6	52	66	

Kg/hr, End - Beginning readings: 592.9

* Calculated by sustracting the immediately previous totalizer reading and time from the reading and time on the current line.

XXX Incorrect reading.

*** Incorrect calculation due to incorrect reading.

EVALUATION OF READINGS
CFB GAGETOWN

READING NO.		1	2	3	4	5	6	7	8
DATE 1985		25.11	25.11	26.11	26.11	27.11	28.11	29.11	1.12
TIME		17:15	20:00	13:45	17:00	13:30	18:00	14:00	9:00
PANEL IND.									
MW FLOW	0-25 MW	9,5	9,5	9,5	9,5	11	14,5	15	10
WATER FLOW	0-100%	38	39	39	40	40	56	55	40
AIR FLOW	0-100%	38	36	38	39	44	76	60	39
GAS INLET HEATER	0-400°C	276	269	290	285	300	364	394	324
GAS OUTLET HEATER	0-400°C	172	167	178	176	182	248	265	203
AIR INLET HEATER	0-400°C	29	29	28	29	29	28	30	28
AIR OUTLET HEATER	0-400°C	161	158	165	166	163	193	219	180
WATER INLET	0-200°C	143	144	141	142	143	142	140	142
WATER OUTLET	0-200°C	179	180	179	179	185	182	183	179
WATER PRESSURE	0-2000kPa	115	110	110	110	109	110	110	112
O_2	0-10	8,2	8,0	8,5	8,0	8,0	7,5	4,0	8,5
DRAFT FURNACE	-100/+100Pa	-40	-35	-40	-40	-40	-40	-40	-40
LOAD FD FAN	0-100 A	21	21	21,5	21,5	22	29	26	22
LOAD ID FAN	0-100 A	21	21	21	21	21	33	27	21
AIR HEATER BYPASS	0-100%	15	0	0	0	0	0	50	0
AIR PRESSURE	MMWG	200	200	200	200	200	160	190	200
CONTROL MEAS.									
PRESS.COMB.CHAMB.	MM WG	-	-	-	-	-	-	-	-
O_2	%	-	-	-	-	-	-	-	-
BACHARACH	-	-	-	-	-	-	-	-	-
TEMP. BOILERHOUSE	°C	24	23	24	24	24	24	28	26
OUTSIDE TEMP.	°C	-5	-6	-4	-4	-3	-4	-4	-9

EVALUATION OF READINGS BURNER NO. 1

CFB GAGETOWN

READING NO.		1	2	3	4	5	6	7	8
DATE 1985		25.11	25.11	26.11	26.11	27.11	28.11	29.11	1.12
TIME		17:15	20:00	13:45	17:00	13:30	18:00	14:00	9:00
PANEL IND.									
TEMP. COAL/AIR	0-200°C	104	108	115	106	107	188	106	100
DRAFT INLET MILL	-100/+25 Pa	-10	-10	-5	-5	-5	-15	-15	-15
DRAFT OUTLET MILL	0-2,5 kPa	1,6	1,6	1,9	1,7	1,6	1,6	1,9	2,1
POS. SEC. AIR	0-100%	85	80	80	80	80	70	65	70
POS. TERT. AIR	0-100%	0	0	30	30	53	60	20	40
POS. PRIM. AIR	0-100%	55	55	60	55	55	55	55	50
POS. COAL FEEDER	0-100%	85	85	80	75	80	71	65	85
POS. EXHAUSTER	0-100%	30	30	40	30	30	25	40	40
POS. OIL FLOW l/hr	0-100%	0	±50	±50	±200	±100	±100	±100	±100
POS. LIMEST. FEEDER	0-100%	0	0	0	0	0	0	0	0
MILL LOAD	0-100A	33	29	28	27	32	30	25	32
CLASSIFIER	0-6	0	0	0	0	0	0	0	0
MILL BYPASS OPEN	0-100%	0	0	0	0	0	0	50	0
FLUE GAS CONE OPEN	0-100%	0	0	0	0	0	0	0	0
CONTROL MEAS.									
POS. AIR SWIRL	0-130 MM	130	130	65	65	65	130	65	65
POS. CORE AIR	0-90°	0	0	0	0	0	0	0	0
PRESS. SEC. AIR	MM WG	-	-	-	-	-	-	-	-
PRESS. TERT. AIR	MM WG	-	-	-	-	-	-	-	-
PRESS. CORE AIR	MM WG	-	-	-	-	-	-	-	-
PRESS. BEFORE DAMP.	MMWG	-	-	-	-	-	-	-	-
SEC. AIR FLOW	MMWG D.P.	29	28	31	30	40	29	17	30
PRIM. AIR FLOW	MMWG D.P.	57	60	80	64	58	51	64	40
OIL FLOW	1-5 V	0	-	-	-	-	-	-	-
OIL PRESS. BEF. B	0-4000 kPa	0	1350	1400	1900	1750	1700	1700	1700
OIL PRESS. AFTER B	0-4000 kPa	1350	1400	1900	1750	500	500	500	500
VV	0-10V	0	4	6	6	6	6	6	5
IR	0-10V	10	10	10	10	10	10	10	10
POS. FEEDER	0-10	7,3	7,4	7,1	6,5	7,0	6,2	5,6	7,0

EVALUATION OF READINGS
CFB GAGETOWN

READING NO.		1	2	3	4	5	6	7	8	9
DATE 1985		2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
TIME		11:30	12:00	12:30	14:00	15:00	15:30	16:30	17:00	18:00
PANEL IND.										
MW FLOW	0-25 MW	10,5	10,5	10,5	10	10	10	10,2	10,5	10,5
WATER FLOW	0-100%	42	42	42	44	44	44	44	48	48
AIR FLOW	0-100%	40	39	39	39	38	38	38	38	38
GAS INLET HEATER	0-400°C	326	333	337	340	347	350	351	352	352
GAS OUTLET HEATER	0-400°C	203	208	210	216	223	225	227	230	230
AIR INLET HEATER	0-400°C	30	30	31	31	30	30	30	30	31
AIR OUTLET HEATER	0-400°C	178	180	184	187	190	191	192	194	191
WATER INLET	0-200°C	148	149	150	150	152	151	150	152	150
WATER OUTLET	0-200°C	186	187	187	186	186	186	186	184	184
WATER PRESSURE	0-2000kPa	110	110	110	110	105	107	109	113	110
O_2	0-10	7,5	6,8	6,3	8,2	7,5	7,6	7,5	7,5	7,5
DRAFT FURNACE	-100/+100Pa	-40	-40	-40	-40	-40	-40	-40	-40	-40
LOAD FD FAN	0-100 A	22	22	22	22	21	21	21	21	21
LOAD ID FAN	0-100 A	21	21	21	21	21	21	21	21	21
AIR HEATER BYPASS	0-100%	0	0	0	0	0	0	0	0	0
AIR PRESSURE	MMWG	200	200	200	200	200	200	200	200	200
CONTROL MEAS.										
PRESS.COMB.CHAMB.	MM WG	-	-	-	-	-	-	-	-	-
O_2	%	-	-	-	-	-	-	-	-	-
BACHARACH	-	-	-	-	-	-	-	-	-	-
TEMP. BOILERHOUSE	°C	24	26	26	24	24	23	23	23	24
OUTSIDE TEMP.	°C	+1	+1	+3	5	4	4	2	2	2

EVALUATION OF READINGS BURNER NO. 1

CFB GAGETOWN

READING NO.		1	2	3	4	5	6	7	8	9
DATE 1985		2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
TIME		11:30	12:00	12:30	14:00	15:00	15:30	16:30	17:00	18:00
PANEL IND.										
TEMP. COAL/AIR	0-200°C	102	100	98	108	104	100	96	96	106
DRAFT INLET MILL	-100/+25 Pa	-10	-10	-10	-15	-15	-15	-15	-20	-20
DRAFT OUTLET MILL	0-2,5 kPa	1,7	1,7	1,6	1,6	1,7	1,6	1,6	1,6	1,6
POS. SEC. AIR	0-100%	80	80	80	80	75	75	75	75	75
POS. TERT. AIR	0-100%	40	40	40	40	40	40	40	40	40
POS. PRIM. AIR	0-100%	53	53	50	50	50	50	50	50	50
POS. COAL FEEDER	0-100%	90	90	90	80	80	80	80	80	80
POS. EXHAUSTER	0-100%	25	25	25	25	25	25	25	25	25
POS. OIL FLOW	0-100%	35	35	35	35	35	35	35	35	35
POS. LIMEST. FEEDER	0-100%	0	0	0	12	12	12	26	26	26
MILL LOAD	0-100A	32	34	35	34	32	31	33	32	30
CLASSIFIER	0-6	0	0	0	0	0	0	0	0	0
MILL BYPASS OPEN	0-100%	0	0	0	0	0	0	50	0	0
FLUE GAS CONE OPEN	0-100%	0	0	0	0	0	0	0	0	0
CONTROL MEAS.										
POS. AIR SWIRL	0-130 MM	65	65	65	65	65	65	65	65	65
POS. CORE AIR	0-90°	0	0	0	0	0	0	0	0	0
PRESS. SEC. AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. TERT. AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. CORE AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. BEFORE DAMP.	MMWG	-	-	-	-	-	-	-	-	-
SEC. AIR FLOW	MMWG D.P.	32	32	32	32	30	30	30	30	30
PRIM. AIR FLOW	MMWG D.P.	47	47	39	40	40	40	40	40	40
OIL FLOW	1-5 V	0	-	-	-	-	-	-	-	-
OIL PRESS. BEF. B	0-4000 kPa	1750	1750	1750	1750	1750	1750	1750	1750	1750
OIL PRESS. AFTER B	0-4000 kPa	500	500	500	500	500	500	500	500	500
VV	0-10V	5	5	5	5	5	5	5	5	5
IR	0-10V	10	10	10	10	10	10	10	10	10
POS. FEEDER	0-10	7,3	7,3	7,3	6,7	6,7	6,7	6,7	6,5	6,6
OIL FLOW	l/h	100	100	100	100	100	100	100	100	100
LIMESTOME FEEDER	Kg/hr	0	0	0	150	150	150	310	310	310

EVALUATION OF READINGS BURNER NO. 2

CFB GAGETOWN

READING NO.		1	2	3	4	5	6	7	8	9
DATE 1985		2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
TIME		11:30	12:00	12:30	14:00	15:00	15:30	16:30	17:00	18:00
PANEL IND.										
TEMP. COAL/AIR	0-200°C	-	-		-					
DRAFT INLET MILL	-100/+25 Pa	-	-		-					
DRAFT OUTLET MILL	0-2,5 kPa	-	-		-					
POS. SEC. AIR	0-100%	0			0					
POS. TERT. AIR	0-100%	0			0					
POS. PRIM. AIR	0-100%	0			0					
POS. COAL FEEDER	0-100%	0			0					
POS. EXHAUSTER	0-100%	0			0					
POS. OIL FLOW l/hr	0-100%	0			0					
POS. LIMEST. FEEDER	0-100%	0			0					
MILL LOAD	0-100A	0			0					
CLASSIFIER	0-6	0			0					
MILL BYPASS OPEN	0-100%	0			0					
FLUE GAS CONE OPEN	0-100%	0			0					
CONTROL MEAS.										
POS. AIR SWIRL	0-130 MM	65	65	65	65					
POS. CORE AIR	0-90°	0	0	0	0					
PRESS. SEC. AIR	MM WG	-								
PRESS. TERT. AIR	MM WG	-								
PRESS. CORE AIR	MM WG	-								
PRESS. BEFORE DAMP.	MMWG	-								
SEC. AIR FLOW	MMWG D.P.	0			0					
PRIM. AIR FLOW	MMWG D.P.	0			0					
OIL FLOW	1-5 V	-								
OIL PRESS. BEF. B	0-4000 kPa	-								
OIL PRESS. AFTER B	0-4000 kPa	-								
VV	0-10V	-								
IR	0-10V	-								
POS. FEEDER	0-10	-								
OIL FLOW	l/h	0	0	0	0					

EVALUATION OF READINGS
CFB GAGETOWN

READING NO.		1	2	3	4	5	6	7	8	9
DATE 1985		3.12	3.12	3.12	3.12	3.12	3.12	3.12	3.12	3.12
TIME		11:30	12:00	12:30	14:00	15:00	15:30	16:30	17:00	20:00
PANEL IND.										
MW FLOW	0-25 MW	16	15,5	15,5	15,5	15	15,5	15	15	15
WATER FLOW	0-100%	60	59	57	58	58	58,5	57,5	57	57
AIR FLOW	0-100%	60	54	60	60	60	60	60	60	60
GAS INLET HEATER	0-400°C	358	363	360	368	368	373	379	376	380
GAS OUTLET HEATER	0-400°C	240	249	253	254	253	256	262	260	260
AIR INLET HEATER	0-400°C	23	20	19	19	19	19	20	20	20
AIR OUTLET HEATER	0-400°C	200	205	209	206	205	208	214	213	215
WATER INLET	0-200°C	138	140	140	142	140	140	140	140	140
WATER OUTLET	0-200°C	178	180	182	184	182	182	180	180	182
WATER PRESSURE	0-2000kPa	110	110	111	114	110	110	110	109	109
O_2	0-10	3,5	2,5	4,6	4	4,5	4	4,5	4,5	4
DRAFT FURNACE	-100/+100Pa	-40	-40	-40	-40	-40	-40	-40	-40	-40
LOAD FD FAN	0-100 A	25	25	25	25	25	25	25	25	25
LOAD ID FAN	0-100 A	25	25	26	27	26	27	26	26	26
AIR HEATER BYPASS	0-100%	0	0	0	0	0	0	0	0	0
AIR PRESSURE	MMWG	180	180	180	180	180	180	180	180	180
CONTROL MEAS.										
PRESS.COMB.CHAMB.	MM WG	-	-	-	-	-	-	-	-	-
O_2	%	-	-	-	-	-	-	-	-	-
BACHARACH	-	-	-	-	-	-	-	-	-	-
TEMP. BOILERHOUSE	°C	23	24	24	22	21	21	21	21	21
OUTSIDE TEMP.	°C	-4	-3	-4	-5	-5	-5	-5	-5	-5

EVALUATION OF READINGS BURNER NO. 1

CFB GAGETOWN

READING NO.		1	2	3	4	5	6	7	8	9
DATE 1985		3.12	3.12	3.12	3.12	3.12	3.12	3.12	3.12	3.12
TIME		14:00	15:00	16:30	17:00	17:30	18:00	19:00	19:30	20:00
PANEL IND.										
TEMP. COAL/AIR	0-200°C	100	103	97	99	104	106	105	103	99
DRAFT INLET MILL	-100/+25 Pa	-20	-30	-20	-20	-20	-25	-20	-20	-20
DRAFT OUTLET MILL	0-2,5 kPa	1,9	1,9	1,8	1,8	1,8	1,7	1,7	1,6	1,7
POS. SEC. AIR	0-100%	66	60	65	65	65	65	65	65	65
POS. TERT. AIR	0-100%	20	20	20	20	20	20	20	20	20
POS. PRIM. AIR	0-100%	50	50	50	50	50	50	50	50	50
POS. COAL FEEDER	0-100%	75	75	85	85	85	85	90	90	90
POS. EXHAUSTER	0-100%	30	35	30	30	30	30	25	25	25
POS. OIL FLOW	0-100%	0	0	0	0	0	0	0	0	0
POS. LIMEST. FEEDER	0-100%	0	0	21	21	21	21	30	30	30
MILL LOAD	0-100A	31	30	32	32	32	32	31	33	33
CLASSIFIER POS.	0-6	0	0	0	0	0	0	0	0	0
MILL BYPASS OPEN	0-100%	0	0	0	0	0	0	0	0	0
FLUE GAS CONE OPEN	0-100%	0	0	0	0	0	0	0	0	0
CONTROL MEAS.										
POS. AIR SWIRL	0-130 MM	65	65	65	65	65	65	65	65	65
POS. CORE AIR	0-90°	0	0	0	0	0	0	0	0	0
PRESS. SEC. AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. TERT. AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. CORE AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. BEFORE DAMP.	MMWG	-	-	-	-	-	-	-	-	-
SEC. AIR FLOW	MMWG D.P.	15	14	16	17	17	17	17	17	17
PRIM. AIR FLOW	MMWG D.P.	35	36	35	36	36	36	36	37	37
OIL FLOW	1-5 V	-	-	-	-	-	-	-	-	-
OIL PRESS. BEF. B	0-4000 kPa	1400	1400	1400	1400	1400	1400	1400	1400	1400
OIL PRESS. AFTER B	0-4000 kPa	100	100	100	100	100	100	100	100	100
VV	0-10V	5	5	5	5	5	5	5	5	5
IR	0-10V	10	10	10	10	10	10	10	10	10
POS. FEEDER	0-10	6,5	6,5	7,2	7,2	7,2	7,2	7,3	7,3	7,3
OIL FLOW	l/h	±50	±50	±50	±50	50	50	50	50	50

EVALUATION OF READINGS BURNER NO. 2

CFB GAGETOWN

READING NO.		1	2	3	4	5	6	7	8	9
DATE 1985		3.12	3.12	3.12	3.12	3.12	3.12	3.12	3.12	3.12
TIME		14:00	15:00	16:30	17:00	17:30	18:00	19:00	19:30	20:00
PANEL IND.										
TEMP. COAL/AIR	0-200°C	98	100	100	106	103	104	94	100	100
DRAFT INLET MILL	-100/+25 Pa	-20	-20	-20	15	-20	-20	-15	-20	-20
DRAFT OUTLET MILL	0-2,5 kPa	1,9	2,0	1,8	1,8	1,8	1,8	1,7	1,7	1,7
POS. SEC. AIR	0-100%	65	60	65	65	65	65	65	65	65
POS. TERT. AIR	0-100%	20	20	20	20	20	20	20	20	20
POS. PRIM. AIR	0-100%	48	50	50	50	50	50	50	50	50
POS. COAL FEEDER	0-100%	85	85	75	75	75	75	75	75	75
POS. EXHAUSTER	0-100%	50	50	45	45	45	45	40	40	40
POS. OIL FLOW	0-100%	0	0	0	0	0	0	0	0	0
POS. LIMEST. FEEDER	0-100%	0	0	21	21	21	21	30	30	30
MILL LOAD	0-100A	34	35	33	32	33	33	33	32	33
CLASSIFIER POS.	0-6	0	0	0	0	0	0	0	0	0
MILL BYPASS OPEN	0-100%	0	0	0	0	0	0	0	0	0
FLUE GAS CONE OPEN	0-100%	0	0	0	0	0	0	0	0	0
CONTROL MEAS.										
POS. AIR SWIRL	0-130 MM	65	65	65	65	65	65	65	65	65
POS. CORE AIR	0-90°	0	0	0	0	0	0	0	0	0
PRESS. SEC. AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. TERT. AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. CORE AIR	MM WG	-	-	-	-	-	-	-	-	-
PRESS. BEFORE DAMP.	MMWG	-	-	-	-	-	-	-	-	-
SEC. AIR FLOW	MMWG D.P.	17	14	15	17	17	17	17	17	17
PRIM. AIR FLOW	MMWG D.P.	32	38	36	36	36	36	36	38	38
OIL FLOW	1-5 V	-	-	-	-	-	-	-	-	-
OIL PRESS. BEF. B	0-4000 kPa	1300	1300	1300	1300	1300	1300	1300	1300	1300
OIL PRESS. AFTER B	0-4000 kPa	100	100	100	100	100	100	100	100	100
VV	0-10V	4	4	4	4	4	4	4	4	4
IR	0-10V	10	10	10	10	10	10	10	10	10
POS. FEEDER	0-10	7	7,7	6,3	6,3	6,3	6,3	6,3	6,3	6,3
OIL FLOW	l/h	±50	±50	±50	±50	50	50	50	50	50

EVALUATION OF READINGS
CFB GAGETOWN

READING NO.	10
DATE 1985	3.12
TIME	20:30
BOILER NO	Br. 2

PANEL IND.

MW FLOW	0-25 MW	15,5
WATER FLOW	0-100%	57
AIR FLOW	0-100%	60
GAS INLET HEATER	0-400°C	392
GAS OUTLET HEATER	0-400°C	268
AIR INLET HEATER	0-400°C	20
AIR OUTLET HEATER	0-400°C	220
WATER INLET	0-200°C	140
WATER OUTLET	0-200°C	182
WATER PRESS.	0-2000 kPa	112
O_2	0-10%	3,5
DRAFT FURNACE	-100/+100 Pa	-40
LOAD FD FAN	0-100 A	25
LOAD ID FAN	0-100 A	27
AIR HEATER BYPASS	0-100%	0
AIR PRESSURE	MM WG	180

CONTROL MEAS.

PRESS. COMB. CHAMB.	MM WG	-
O_2	%	-
BACHARACH	-	-
TEMP. BOILER HOUSE	°C	21
OUTSIDE TEMP.	°C	0

EVALUATION OF READINGS BURNER NO. 1

CFB GAGETOWN

READING NO.		10
DATE 1985		3.12
TIME		20:00

PANEL IND.

TEMP. COAL/AIR	0-200°C	103
DRAFT INLET MILL	-100/+25 Pa	-20
DRAFT OUTLET MILL	0-2,5 kPa	1,6
POS. SEC. AIR	0-100%	65
POS. TERT. AIR	0-100%	20
POS. PRIM. AIR	0-100%	50
POS. COAL FEEDER	0-100%	85
POS. EXHAUSTER	0-100%	25
POS. OIL FLOW l/hr	0-100%	0
POS. LIMEST. FEEDER	0-100%	30
MILL LOAD	0-100A	33
CLASSIFIER	0-6	0
MILL BYPASS OPEN	0-100%	0
FLUE GAS CONE OPEN	0-100%	0

CONTROL MEAS.

POS. AIR SWIRL	0-130 MM	65
POS. CORE AIR	0-90°	0
PRESS. SEC. AIR	MM WG	-
PRESS. TERT. AIR	MM WG	-
PRESS. CORE AIR	MM WG	-
PRESS. BEFORE DAMP.	MMWG	-
SEC. AIR FLOW	MMWG D.P.	17
PRIM. AIR FLOW	MMWG D.P.	37
OIL FLOW	1-5 V	-
OIL PRESS. BEF. B	0-4000 kPa	1400
OIL PRESS. AFTER B	0-4000 kPa	100
VV	0-10V	5
IR	0-10V	10
POS. FEEDER	0-10	7,3
OIL FLOW	l/h	50

EVALUATION OF READINGS BURNER NO. 2

CFB GAGETOWN

READING NO.		10
DATE 1985		3.12
TIME		20:30
PANEL IND.		
TEMP. COAL/AIR	0-200°C	94
DRAFT INLET MILL	-100/+25 Pa	-20
DRAFT OUTLET MILL	0-2,5 kPa	1,7
POS. SEC. AIR	0-100%	65
POS. TERT. AIR	0-100%	20
POS. PRIM. AIR	0-100%	50
POS. COAL FEEDER	0-100%	75
POS. EXHAUSTER	0-100%	40
POS. OIL FLOW l/hr	0-100%	0
POS. LIMEST. FEEDER	0-100%	30
MILL LOAD	0-100A	33
CLASSIFIER	0-6	0
MILL BYPASS OPEN	0-100%	0
FLUE GAS CONE OPEN	0-100%	0
CONTROL MEAS.		
POS. AIR SWIRL	0-130 MM	65
POS. CORE AIR	0-90°	0
PRESS. SEC. AIR	MM WG	-
PRESS. TERT. AIR	MM WG	-
PRESS. CORE AIR	MM WG	-
PRESS. BEFORE DAMP.	MMWG	-
SEC. AIR FLOW	MMWG	D.P. 17
PRIM. AIR FLOW	MMWG	D.P. 38
OIL FLOW	1-5 V	-
OIL. PRESS. BEF. B	0-4000 kPa	1300
OIL PRESS. AFTER B	0-4000 kPa	100
VV	0-10V	4
IR	0-10V	10
POS. FEEDER	0-10	6,3
OIL FLOW	l/h	50

Examination of Selected Ash Samples

Three samples which had been treated with calcium carbonate before burning were selected for examination to observe the relative amounts of calcium carbonate remaining.

Samples chosen were:

A. Unit #2: 1 Dec. 3:45 p.m. (Ca/S: 3/1)
B. Unit #2: 3 Dec. 6:30 p.m. (Ca/S: 2.5/1)
C. Unit #2: 3 Dec. 8:30 p.m. (Ca/S: 2.5/1)

X-ray diffraction studies indicated that all products contained calcium carbonate: it is difficult to attach accurate quantitative values to x.r.d. traces, but it was observed that the calcium carbonate peak in Sample A was substantially more intense than those in B and C, which would appear to indicate that a 2.5/1 ratio of calcium carbonate to sulfur is sufficient.

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/mb

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